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EFFECT OF ADSORBED ELECTROLYTES ON PROPERTIES OF MONODISPERSE CLAY-WATER SYSTEMS*

By S. Speil

Abstract

A sample of Florida kaolin was separated by a supercentrifuge into three nearly monodisperse systems whose sizes were, respectively, 0.1 to 0.2, 0.2 to 0.4, and 0.4 to 1.0 micron. These samples were electrodialyzed, and to aliquot samples of the H clay thus obtained, varying concentrations of sodium or barium hydroxide were added.

The base-exchange capacity at pH 7 varied linearly with the surface area. The apparent viscosity was reduced to about 4% of its original value by the addition of 1 milliequivalent of sodium hydroxide, after which further additions had a very slight lowering effect. The addition of electrolyte decreased the yield point and increased the maximum strain before rupture at the water content of optimum plasticity. The water of plasticity, pore water, shrinkage water, and film thickness were decreased by adding electrolyte. The dry transverse strength was doubled by the change from H clay to Na clay. Most properties varied linearly with the surface area within the experimental error. The potential concept of plasticity is briefly outlined.

I. Introduction

It has become increasingly evident that further study of the plastic properties of clay must be carried on in such manner that the effects of the individual factors affecting these properties are shown. Among the contributing factors which have been studied are particle size,[1] particle shape,[2] type of dispersing medium,[3] and amount of electrolyte.[4]

Henry and Taylor[4] investigated the viscosity relations of several American clays, showing how the viscosity varied with NaOH concentration. Klinefelter, Meyer, and Vachuska[5] show a rough analogy between changes in base-exchange capacity at pH 7, percentage of material less than 0.6 micron in diameter, dry transverse strength, and volume drying shrinkage. These same authors noted a linear relation between base-exchange capacity at pH 7 and the tensile strength. Endell, Hofmann, and Wilm[6] bring out a simple graphical relation between base-exchange capacity and plasticity as measured by the Rieke number.

If, however, the properties of several clay samples are to be compared in order to understand the reasons for the differences between them, the factors which complicate observed phenomena cannot be tacitly neglected and variations cannot be attributed to one factor alone. A definite attempt has been made in this work to eliminate to some extent the effects of the variables which have not been studied.

A large sample of Florida kaolin (E.P.K.) was dispersed in distilled water with a dispersing agent and was fractionated into three nearly monodisperse systems all under 1 micron in size. These fractions were electrodialyzed to obtain hydrogen clay, various additions of electrolyte were made to aliquot portions, and measurements were made of the base-exchange capacity, viscosity, plasticity, drying shrinkage, and dry transverse strength. That certain correlations between these properties are possible is shown by the experimental results obtained.

II. Preparation of Clay

(1) Fractionation

The clay was first suspended with 1% Daxad. To insure complete deflocculation, the suspension was examined microscopically. After the particles of more than one micron were removed by settling in large galvanized cans, the fines were run through a Sharples supercentrifuge at 8500 revolutions per minute and at a fluid velocity of 50 cc. per minute. By repeated centrifuging, three fractions were produced whose sizes, calculated according to the method of Hauser and Reed,[7] were 0.1 to 0.2, 0.2 to 0.4, and 0.4 to 1.0 micron, respectively. The cumulative size-distribution curves for these fractions determined by the centrifuge method of Norton and Speil[8] are given in Fig. 1. In making comparisons between the fractions, it is simpler to use the total surface per 100 grams of clay. If the diameter determined by sedimentation is assumed to be the har-

* Presented at the Forty-First Annual Meeting, American Ceramic Society, Chicago, Ill., April 18, 1939 (Materials and Equipment Division). Received April 14, 1939.

[1] H. Whittaker, "Effect of Particle Size on Plasticity of Kaolinite," *Jour. Amer. Ceram. Soc.*, **22** [1] 16–23 (1939).

[2] E. O. Wilson, "Plasticity of Finely Ground Minerals with Water," *ibid.*, **19** [4] 115–20 (1936).

[3] Erhard Gruner, "Adsorption Systems of Kaolin and Clays with Liquids in Relation to Plasticity," *Z. anorg. allgem. Chem.*, **215** [1] 1–18 (1933); *Ceram. Abs.*, **13** [4] 101 (1934).

[4] E. C. Henry and N. W. Taylor, "Acid and Base Binding Capacities and Viscosity Relations in Certain Whiteware Clays," *Jour. Amer. Ceram. Soc.*, **21** [5] 165–75 (1938).

[5] T. A. Klinefelter, W. W. Meyer, and E. J. Vachuska, "Some Properties of English China Clays," *ibid.*, **16** [6] 269–76 (1933).

[6] K. Endell, U. Hofmann, and D. Wilm, "Nature of Ceramic Clays," *Ber. deut. keram. Ges.*, **14** [10] 407–38 (1933); *Ceram. Abs.*, **13** [4] 101 (1934).

[7] E. A. Hauser and C. E. Reed, "Studies in Thixotropy," *Jour. Phys. Chem.*, **40** [9] 1169–82 (1936).

[8] F. H. Norton and S. Speil, "Measurement of Particle Sizes in Clays," *Jour. Amer. Ceram. Soc.*, **21** [3] 89–97 (1938).

monic mean as suggested by Wilson and Middleton,[9] a rectangular plate, with sides a, b, and c, results as follows:

$$3/d = 1/a + 1/b + 1/c.$$

For the surface between two diameters, D_1 and D_2, the relation is

$$S = \frac{6}{\rho}\int_{D_1}^{D_2} \frac{1}{d} \cdot \frac{dW}{dD} \cdot dD.$$

This relation may be integrated graphically, giving the values as follows:

Column (1), fraction; (2), area per 100 grams (cm.^{2} × 10^4).

(1)	(2)
1	1510
2	900
3	590

To make sure that the mineralogical constitution of the fractions was the same, X-ray diffraction patterns were made and compared with those of standard minerals. The fractions proved to be essentially kaolinite. Ordinary microscopic examination was not applicable because of the particle size involved. Thermal-analysis curves[10] of the fractions were practically identical.

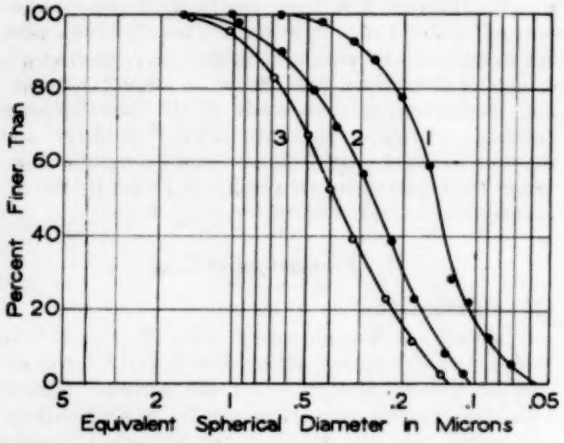

FIG. 1.—Particle-size curves for the three fractions.

(2) Electrodialysis

The clay was placed in the center compartment of a three-compartment electrodialysis cell with a potential gradient of 90 volts per inch. Distilled water flowed continuously through the end cells at the rate of one liter per hour which prevented building up any ionic concentration. The electrodialysis was carried on for approximately five days. It was considered complete when phenolphthalein failed to give a basic reaction with the catholyte after a ten-hour uninterrupted run with no liquid flowing through the end cells. The 10% suspension in the center compartment was stirred throughout the run by a moving paddle arrangement which prevented the clay from depositing on the bottom and sides of the compartment because of electrodecantation.

The electrodialyzed hydrogen clay was stored wet because a small sample of the dried fine fraction was difficult to redisperse completely. Paraffin-lined containers were used to prevent the contamination of the H clay.

The correct amount of water and 0.1 N NaOH was added to bring aliquot samples of the clay to the desired electrolyte concentration for the plasticity, dry shrinkage, and dry strength. The samples for viscosity and pH determinations were prepared separately. Inasmuch as continuous additions of base to the clay are not possible,[4] a series of samples containing 10 grams of clay in 50 grams of suspension was prepared and stored in closed glass containers for 48 hours before measurement. The suspensions were frequently agitated during this period.

III. Experimental Methods

A MacMichael viscosimeter was used because it is easy to operate, it covers a large range, only a small sample is necessary, and precision readings are obtained. The device is also easily calibrated by using liquids of known viscosity.

The two fundamental attributes of viscosity are yield point and mobility, either of which may change with the addition of electrolyte. The results, like those of Henry and Taylor, will be given in terms of "apparent viscosity," which may be defined simply as the viscosity of a Newtonian liquid that gives the same deflection of the torsion head when the outer cup is rotated at the same speed as when filled with slip. Because the outer cylinder was rotated at a constant speed of 80 r.p.m. throughout the experiments, the apparent viscosities are comparable among each other.

The colorimetric and electrometric methods are available for pH determinations. The former method, however, is not feasible because of the turbid suspensions and the impracticability of using ultrafiltrates from the slip. Of the electrical methods, the quinhydrone electrode received scant consideration because it is useful only for acid suspensions. The glass electrode was selected over the hydrogen electrode because it is simpler and is sufficiently accurate for the purpose desired.

The Coleman pH meter, a portable meter with a vacuum-tube amplifier, was used for accurate readings over the range studied. This instrument has an automatic temperature compensator and needs only to be checked with a potassium acid phthalate buffer before use. The pH measurements were made on the same samples as the viscosity determinations as soon after the latter as possible, although readings taken twenty-four hours afterward checked very well.

[9] Hewitt Wilson and G. J. Middleton, "Purification of Kaolin: Data on Classification of Quartz and Muscovite," *Jour. Amer. Ceram. Soc.*, **20** [4] 126–35 (1937).

[10] F. H. Norton, "Critical Study of Differential Thermal Method for Identification of Clay Minerals," *ibid.*, **22** [2] 54–63 (1939).

The determination of plasticity was made on the torsion apparatus described by Norton.[11] A small wad of clay was wrapped around a glass tube, $^5/_8$ inch in outer diameter, and was rolled out on a smooth piece of wood with guide rails to give a hollow cylinder of clay of $^1/_8$ inch wall thickness. The test method was similar to that described by Norton.[11]

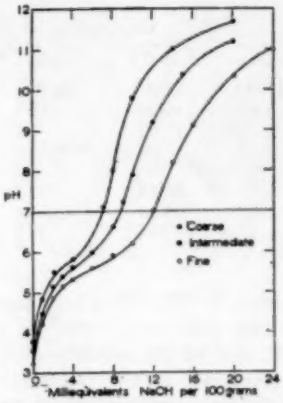

FIG. 2.—Titration curves for the three fractions.

The drying shrinkage determinations were made on an apparatus designed by Norton,[12] using hollow cylindrical samples similar to the plasticity specimens.

The dry strength was measured on a simple transverse-strength apparatus with specimens approximately $2^1/_2$ by $^1/_2$ by $^1/_4$ inch with $1^1/_2$ inches between the supports. These specimens were dried at room temperature for 48 hours, placed in a drier at 105°C. for 24 hours, and the samples were cooled in a desiccator and tested. The width and depth at the point of fracture were measured at several points with vernier calipers.

IV. Experimental Results

(1) Titration Curves

Figure 2 gives the results of the pH measurements, using a 20% clay concentration. The change in ultimate pH showed a decrease in acidic tendency with increasing particle size. The titration curves are typical of those obtained with a weak acid and a strong base. The base-exchange capacity at pH 7 increased with decreasing particle size, as was expected, giving values of 7.0, 8.7, and 12.0, respectively, for the three fractions.

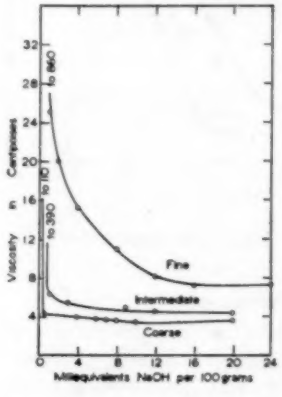

FIG. 3.—Viscosity curves for fractionated kaolin.

(2) Viscosity

The apparent viscosity was plotted against the number of milliequivalents of NaOH per 100 grams of clay (Fig. 3). The curves show that the coarse fraction is the most easily deflocculated. Although samples were made up using the fraction of intermediate size and $Ba(OH)_2$ as an electrolyte, no viscosity values are reported here. The samples showed definite thixotropic phenomena, and therefore viscosity measurements would have been worthless without a more complicated and detailed experimental technique. The importance, however, of the study of thixotropic behavior in general is not to be underestimated. It was omitted merely because it was not within the scope of the present work.

(3) Plasticity

The dialyzed hydrogen clay was quite plastic (the more plastic, the finer the size). With small electrolyte concentrations added, the clay becomes softer, and with small additions of water, the Na clay could be transformed from a fairly plastic mass to a sticky paste. The increase of NaOH and of particle size favored a tendency toward flabbiness; the coarse Na clay could be formed into plasticity specimens only with difficulty because of its low yield value. The addition of $Ba(OH)_2$ seemed to give a more plastic mass.

Typical plasticity curves are given in Figs. 4 and 5. Because of the fairly large variations in individual plasticity tests on the same fraction, actual plasticity determinations were made only on the H, Na, and Ba clays. The change in yield value and maximum strain before rupture with change in water content followed the same trend shown by Whittaker.[1] Table I gives the plasticity data.

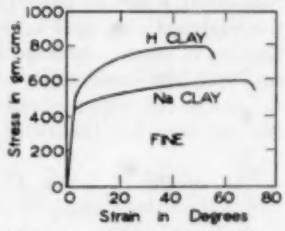

FIG. 4.—Stress-strain diagram for fine clay.

The value calculated for film thickness depends entirely on the assumptions made. Set (1) in Table I was calculated by assuming infinitely thin plates separated by a film of the thickness given; set (2) was calculated by assuming a square plate with the thin dimension one-tenth of the square side and by assuming a packing in which two-thirds of the particles joined lengthwise and one-third of the particles packed flat.

The yield point was definitely lowered by additions of electrolyte, NaOH being more effective than $Ba(OH)_2$. The extension before rupture was increased by the addition of electrolytes. The product of these two factors, which gives some measure of the ordinary idea of plasticity or workability, does not show any definite change except in the case of the Ba clay.

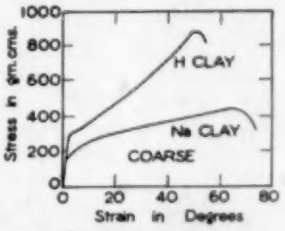

FIG. 5.—Stress-strain diagram for coarse clay.

(4) Drying Shrinkage

The drying shrinkage curves for the three fractions

[11] F. H. Norton, "Instrument for Measuring Workability of Clays," *Jour. Amer. Ceram. Soc.*, **21** [1] 33–36 (1938).
[12] F. H. Norton, "Precise Measurement of Drying Shrinkage," *Ceram. Age*, **33** [1] 7–8 (1939); *Ceram. Abs.*, **18** [10] 276 (1939).

are given in Fig. 6; the maximum water content shown, which is not necessarily that of optimum plasticity, merely indicates the point at which readings were begun.

(5) Dry Strength

Figure 8 shows the change in dry strength with increase of electrolyte up to the saturation point. The average percentage deviation of the experimental values indicated is approximately 7%. The fact that the value determined for the transverse strength is somewhat dependent on the size of the specimen and on the testing technique gives rise to the possibility that these values may not be comparable to those determined with a larger cross-section specimen. Even if the values are considered to be only relative to each other, they fulfill the desired purpose.

TABLE I

PLASTICITY DATA ON SETS (1), (2), AND (3)

Type of clay	Fraction (1) H	Fraction (1) Na	Fraction (2) H	Fraction (2) Na	Fraction (2) Ba	Fraction (3) H	Fraction (3) Na
Optimum plasticity (gm.-cm.-deg.)	29,000	31,000	18,000	20,000	27,000	15,000	12,500
At optimum plasticity yield	520	450	480	270	425	300	175
At optimum plasticity strain	55	70	37	75	65	50	70
Surface (per 100 gm. × 10^4 sq. cm.)	1510		900			590	
Avg. particle size (equivalent spherical diameter, μ)	0.15		0.28			0.45	
Film thickness at optimum plasticity (Å) (1)	610	450	720	500	590	780	640
Film thickness at optimum plasticity (Å) (2)	170	125	260	195	220	355	315

Figure 7 shows the effect on the shrinkage curves caused by adding increasing amounts of NaOH to the intermediate fraction. The curve obtained for the clay containing 1 m.e. of NaOH differed little from that for the dialyzed clay and is omitted for clearness. The families of curves obtained for the other fractions were similar. The nonlinearity of the upper portion of the shrinkage curve is probably due to the fact that the samples were not preheated to the test temperature of 65°C.

The results of Table II were calculated from the shrinkage values and other data.

TABLE II

EFFECT OF PARTICLE SIZE AND ELECTROLYTES

Column (1), water of plasticity; (2), shrinkage water; (3), pore water.

Fine fraction	(1)	(2)	(3)
H clay	78	46	32
Na clay	58	34	24
Intermediate clay			
H clay	70.5	32.5	38
M.e./100 gm.			
1 NaOH	69	31	38
6 NaOH	57	24.5	32.5
8.5 NaOH	55	24	31
10 NaOH	52	22.5	29.5
6 $Ba(OH)_2$	63	27	36
10 $Ba(OH)_2$	61	26.5	34.5
Coarse clay			
H clay	62	22	40
M.e./100 gm.			
1 NaOH	60	22	38
4.5 NaOH	54	21.5	32.5
7 NaOH	50	19	31

These values show a definite decrease in pore water with decrease in particle size and with increase in electrolyte content. There is also a tendency toward decreased shrinkage water as the amount of electrolyte or the particle size is increased.

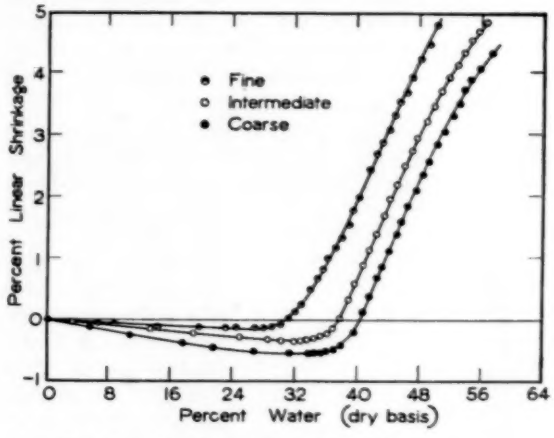

FIG. 6.—Shrinkage curves for hydrogen clay.

V. Discussion

The change in the titration curves with particle size would be expected as the decrease in size gives more surface area per unit mass and, therefore, a greater number of surface ions to be neutralized in the titration. Because of the marked change in base-exchange capacity at pH 7, similar to that observed by Kelley and Jenny,[13] most of the exchange seems to takes place at the surface, and there is only a relatively small amount of internal exchange.

[13] W. P. Kelley and Hans Jenny, "Relation of Crystal Structure to Base Exchange and Its Bearing on Base Exchange in Soils," *Soil Sci.*, **41**, 367–82 (1936).

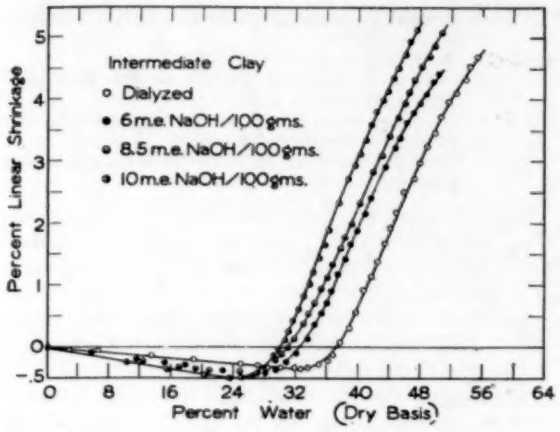

FIG. 7.—Effect of electrolyte concentration on shrinkage.

The viscosity and plasticity of clay-water systems have been attributed to various types of solvation phenomena or special aggregation forces. One explanation of high viscosities often encountered is the aggregation of particles which cause voluminous, loosely connected masses of large apparent volume.[14] Another possible mode of explanation is that some dispersion medium may be held and immobilized on the surface by adsorption or solvation.

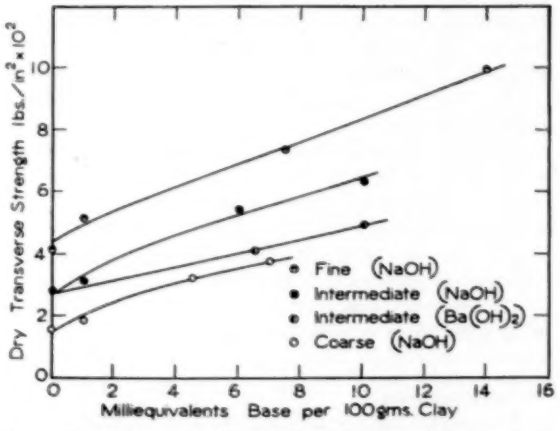
Dry Transverse Strength lbs./in.² x 10²
• Fine (NaOH)
• Intermediate (NaOH)
• Intermediate (Ba(OH)₂)
o Coarse (NaOH)
Milliequivalents Base per 100 gms. Clay

FIG. 8.—Effect of electrolyte concentration on dry strength.

In the case of plastic masses, the thickness of water films around the particles may be calculated. This film thickness tends to become smaller when the amount of NaOH is increased, although the Na^+ ion is solvated to a greater extent than H^+. It does not seem possible that solvation by the adsorbed cations can explain fully the presence of water films. It seems more reasonable to assume with Houwink[15] that "In this way, we may explain the phenomenon that the clay particles are by preference situated at some distance from each other, as being the result of an equilibrium of repulsive and attractive forces, whereby the system seeks as far as possible to reach a minimum in potential energy. The fact that the space between the particles is filled with water gives the impression that there is a water film between the particles."

The entire problem may be treated in this way from the potential viewpoint of Hamaker.[16] The potential curve for two particles may be calculated with the assumption of the following potentials: (1) A Van der Waals attraction potential, represented by c/r^2; (2) an electrical repulsion potential caused by the interpenetration of diffuse ionic atmospheres and represented by

$$\psi = \frac{be^{-ar}}{r}.$$

Wherein b = measure of density charge.
a = a constant proportional to the square root of ionic concentration and other factors.
r = distance between particles;

and (3) a repulsion according to some high negative power of r and acting at small values of r.

The summation of these three potentials gives a potential curve of the type represented in Fig. 9. The first minimum corresponds to small distances between particles or to coagulation. The second minimum is the equilibrium position for stability. The depth of this minimum probably will control the yield value of a plastic clay mass. By addition of OH^- ions, the charge on the particles is increased as well as factor b of the repulsion potential. Because the attraction potential is not affected, the potential minimum will become more shallow and the clay will exhibit a lower yield value, shown by the experimental data. The depth of this minimum in the curve should also affect the viscosity. Because of changes in electroviscous effects and because of the agglomeration of particles, the change in viscosity is not so simply related to the minimum in the curve as is the yield value. Although the potential theory is still in its infancy and requires more experimental data to establish its validity, it seems to be a logical and promising approach to plastic phenomena.

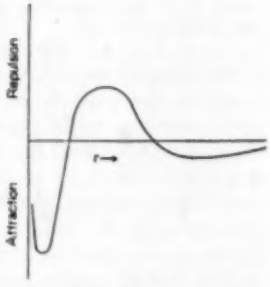

FIG. 9.—Potential curve of Hamaker.

[14] W. K. Lewis, Lombard Squires, and W. I. Thompson, "Colloidal Properties of Clay Suspensions," *Trans. Amer. Inst. Mining Met. Engrs.*, **114**, 38–52 (1935); *Ceram. Abs.*, **17** [3] 115 (1938).

[15] R. Houwink, Elasticity, Plasticity, and Structure of Matter; chapter on "Clay." University Press, Cambridge, England, 1937; *Ceram. Abs.*, **17** [6] 235 (1938).

[16] H. C. Hamaker, "General Theory of Lyophobic Colloids," *Rec. trav. chim.*, **55**, 1015–26 (1936); **56**, 1–25 (1937).

The drying shrinkage possibly may be related roughly to the degree of deflocculation; e.g., as the clay mass dries, the liquid is removed from the capillaries and the particles tend to rearrange themselves to give the most stable structure or minimum free energy. As NaOH is added, the repulsion potential is increased without affecting the attraction potential. The relative decrease in attraction between the particles possibly would allow them to come into better relation to each other by the time the water had been removed from the capillaries and the particles were touching. By this reasoning, a flocculated clay mass, wherein the attractive forces pull the particles together into a random arrangement before they can reach stable positions, would be expected to give a relatively high pore water value.

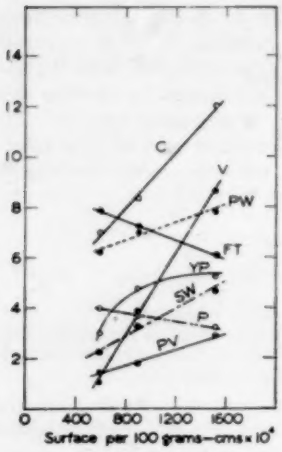

FIG. 10.—Effect of surface area on properties of hydrogen clay.

Even though a mass of spherical particles of any one size should theoretically pack so as to give the same percentage voids, regardless of the size of the particles, the fact that the fractions do cover a definite size range and that they are really platelike leads to the reasonable conclusion that the finer fraction in drying should show less pore water.

The dry strength of clays is still a difficult matter to explain. As the NaOH content is increased, the pore water is decreased as shown by the shrinkage curves, which should give a test piece with a more uniform cross-sectional area as the NaOH is increased to the saturation point. The adsorbed ions also may act possibly as a sort of cementing material, binding the particles together in the dry state.

VI. Conclusions

The conclusions from the present work may be divided into two groups in which one series shows the effect of particle size and the other, the effect of electrolyte addition. The relation between the particle size and the various properties of the H clay are shown in Fig. 10. The curves are as follows:

C = base-exchange capacity at pH 7 (m.e. NaOH).
PW = water of plasticity based on dry weight (% × 10).
FT = film thickness at optimum plasticity (Angstrom units × 10^2).
V = viscosity (centipoises × 10^2).
YP = yield point at water content of optimum plasticity (gm.-cm. × 10^2).
SW = shrinkage water based on dry weight (% × 10).
P = pore water based on dry weight (% × 10).
PV = plasticity value at optimum plasticity (gm.-cm. degrees × 10^4).

In most cases, the three points corresponding to the three fractions studied could be joined by a straight line within the experimental error of the measurements. It is unfortunate that at least one more fraction was not prepared to ascertain whether the linear relations observed could be extrapolated to any extent, especially in the case of the base-exchange curve.

Concerning the effect of electrolytes, the following conclusions may be drawn for the clay studied with electrolyte additions up to the saturation point.

(1) The viscosity is decreased by adding NaOH. The addition of 1 m.e. of NaOH decreases the value to approximately 4% of that of the H clay; further additions have only a minute effect in lowering the viscosity. The use of $Ba(OH)_2$ with a 20% solid suspension causes definite thixotropic behavior.

(2) The yield point at the water content of maximum plasticity decreases with increasing electrolyte content.

(3) The maximum strain before rupture at optimum plasticity increases with increasing electrolyte concentration.

(4) The water of plasticity decreases with increasing electrolyte content. The Na clay requires approximately 75% of the water necessary for optimum plasticity with the H clay.

(5) The pore water decreases with increasing electrolyte content.

(6) The shrinkage water decreases with increasing electrolyte content.

(7) The film thickness between particles at optimum plasticity is decreased by adding electrolyte.

(8) The dry strength of the clay is increased by as much as 100% by changing H clay to Na clay.

(9) In every property measured, the effect of monovalent Na^+ ions was greater than that of divalent Ba^{++} ions.

Acknowledgment

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EFFECT OF EXCHANGEABLE BASES ON TORSION PROPERTIES OF CLAYS*

By John D. Sullivan and Robert P. Graham

Abstract

Torsion properties of a plastic fire clay, a ball clay, two flint fire clays, a bentonite, and Georgia kaolin were studied. The effect of exchangeable bases on the surface of the clay particles on stress-strain relationships was established. The widest differences, in general, were found in the sodium and hydrogen forms of the various bodies. A rational explanation of the behavior of clays with different exchangeable bases lies in the fact that their colloidal natures govern to a large degree their workable characteristics, and colloidal properties, in turn, are dependent on the water film surrounding the particle. The nature of the water film is influenced by the kind and the nature of the charges in the ion atmosphere surrounding the particles and may be changed by replacing an exchangeable base with another cation.

I. Introduction

This paper is another in a series on a general study of base-exchange phenomena in clays. Earlier papers described methods of determining exchangeable bases and of base-exchange capacity,[1] the torsion apparatus and experimental technique used,[2] stress-strain relationships on six clays with varying water content in the workable stiff-mud range,[3] and the role of colloidal properties in controlling physicochemical properties of clays.[4] This paper considers the effect of exchangeable bases on the torsion properties of the same six clay bodies used in earlier studies.[3] For convenience (although they have been reported[1]) the chemical analyses are given in Table I and the analyses of exchangeable bases in Table II. Because the details of experimental procedure in making torsion tests have been described in earlier papers, they will not be repeated; stress-strain curves are not given in this paper.

The phenomenon of base exchange is the replacement of bases or cations in or on a body by other cations. A general equation for exchange of ions is as follows:

$$bM^{a+} + aM_1^{b+} \rightleftarrows aM^{b+} + bM_1^{a+}.$$

Wherein a^+ and b^+ = cations.
M and M_1 = molecules.

The reaction is reversible and follows a modified mass action law for univalent and divalent cations. As the concentrations at the surface are high, the ordinary laws for dilute solutions do not hold rigorously. Paver and Marshall[5] state that some trivalent cations, such as La and Fe, react with unsaturated clays to enter a normal exchange reaction, but Al cation does not react with hydrogen clays in this manner. Exchangeable Al cation, however, is liberated from clays by neutral salts, but H is simultaneously liberated. An extensive study of exchangeable bases in soils was made by Magistad,[6] who concluded that in the case of artificial zeolites the bases present were released by neutral or acid solutions of iron and aluminum salts. The residue, however, contained no hydrogen zeolite, nor did ferric iron or aluminum enter the zeolite complex in such a manner as to be replaced by other replacing agents subsequently used.

Two distinct types of base-exchange reactions are recognized. The first, exemplified by all negatively charged colloids, is the simple replacement of one cation in the outer Helmholtz double layer by another cation. In the second type, cations of the crystal lattice are replaced by other cations which assume the geometric position of those displaced, yielding a lattice with optical properties that differentiate it from the original. The two forms generally are regarded as distinct though isomorphous species. Most clays probably exhibit exchange phenomena of the first type only, although work done at the Battelle Memorial Institute on the electrodialysis of bentonite indicated that it may have exchangeable ions of the second type.

Cations are concentrated at the surface of clay particles and are not at liberty to move freely. Even though the exchange capacity may be fairly low the concentrations at the surface may be high.

II. Experimental Work

Briefly stated, the torsion test comprised extruding a deaired clay bar in the stiff-mud consistency range, forming the bar so as to hold it in the torsion machine in such manner that in testing failure occurs at the center of the bar, then distorting it in torsion in a motor-driven machine, the chuck of which rotated at 3 r.p.m. A spring-loading device resisted and measured the torque transmitted through the bar, and a continuous curve of torque vs. angular deformation was

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[1] R. P. Graham and J. D. Sullivan, "Critical Study of Methods of Determining Exchangeable Bases in Clays," *Jour. Amer. Ceram. Soc.*, **21** [5] 176–83 (1938).

[2] R. P. Graham and J. D. Sullivan, "Improved Machine Shows Different Forms of Failure of Clay Bodies in Torsion," *Bull. Amer. Ceram. Soc.*, **18** [3] 97–100 (1939).

[3] R. P. Graham and J. D. Sullivan, "Workability of Clays," *Jour. Amer. Ceram. Soc.*, **22** [5] 152–56 (1939).

[4] J. D. Sullivan, "Physico-Chemical Control of Properties of Clays," *Trans. Electrochem. Soc.*, **75**, 71–98 (1939).

[5] H. Paver and C. E. Marshall, "Role of Aluminum in Reactions of Clays," *Chem. & Ind.*, **53** [36] 750–60 (1934); *Ceram. Abs.*, **15** [11] 346 (1936).

[6] O. C. Magistad, "Action of Aluminum, Ferrous and Ferric Iron, and Manganese in Base-Exchange Reactions," *Arizona Agr. Expt. Sta. Tech. Bull.*, **18**, 445–63 (1928); *Ceram. Abs.*, **8** [1] 72 (1929).

TABLE I

CHEMICAL ANALYSIS OF CLAY BODIES

Clay	Ingredient (%)									
	Ignition loss	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O	S
Lawrence plastic	8.44	59.19	1.85	25.51	1.46	0.40	0.85	0.30	1.99	0.18
Ky. flint	13.53	44.35	1.41	37.36	2.04	0.28	0.58	0.47	0.55	0.14
Pa. flint	13.12	44.37	1.61	36.85	2.94	0.23	0.56	0.33	0.85	0.08
Ky. ball	12.88	51.85	1.65	29.79	1.44	0.32	0.63	0.22	0.75	0.05
Wyo. bentonite	6.04	63.64	4.13	18.92	0.28	0.81	2.41	2.47	0.43	0.16
Ga. kaolin (Wilkinson County)	13.77	44.71	0.90	38.60	0.51	0.15	0.32	0.07	0.14	Trace

TABLE II

ANALYSIS OF EXCHANGEABLE BASES OF CLAY BODIES

Component	Exchangeable metallic bases (m.e./100 gm.)					
	Ga. kaolin	Pa. flint fire clay	Ky. flint fire clay	Lawrence plastic fire clay	Ky. ball clay	Wyo. bentonite*
Calcium	0.4	2.5	3.4	5.2	7.1	
Magnesium	0.6	1.8	2.0	1.3	3.8	
Sodium	0.1	0.5	0.9	0.4	0.5	
Potassium	Trace	0.4	0.8	0.5	0.4	
Sum	1.1	5.2	7.1	7.4	11.8	
Determination by	Total metallic exchangeable bases (m.e./100 gm.)					
Proximate carbonate method	0.9	5.1	6.7	7.7	12.3	
	Base-exchange capacity (m.e./100 gm.)					
Ammonia distillation	2.5	7.1	7.9	10.8	14.4	74.3
	Exchangeable hydrogen (m.e./100 gm.)†					
	1.6	2.0	1.2	3.1	2.1	

*As stated in an earlier paper,[1] the exact analysis of individual cations in bentonite is questionable, owing to presence of large amounts of soluble salts.

† Base-exchange capacity minus total metallic exchangeable bases.

drawn by a stylus on a smoked-glass plate. The torsion data are the average of at least four bars. Three water contents were used to give moderately dry, medium, and fairly wet or soft bodies in the stiff-mud range.

To simplify the factors involved, the clay should first be converted to the hydrogen form and the hydrogen clay should be changed to the desired base form. Soluble salt effects are thus eliminated if oxides or hydroxides are used in making the base. For example, to make a Na clay from H clay, NaOH may be employed and the product of reaction is H_2O, whereas if the initial clay were Ca clay the reaction product would be $Ca(OH)_2$. In the work described in this paper, the raw clays were converted to the hydrogen form, and H clay was used as the starting point for the formation of the other base bodies studied.

A raw clay may be converted to the hydrogen form by electrodialysis or by leaching with an excess of acid. Both methods have been used at Battelle, but the acid process was used in these studies.

The term "H clay" refers to the product in which substantially 100% of the exchangeable bases are replaced by hydrogen; "100% Na clay" refers to the product resulting from treating H clay with NaOH in an amount equivalent to the base-exchange capacity of the clay. Similarly, 75% Na clay indicates that 75% of the theoretical amount of NaOH was added to H clay. All other base designations are on a similar basis.

All of the data given here, except Figs. 1, 2, 3, 4, and 22, and part of Table III, are new and are being reported for the first time. These results on Lawrence clay are repeated[7] for the sake of completeness and so that general comparisons, such as those in Figs. 19, 20, and 21, may be given.

(1) Preparation of Bodies

(*A*) *Lawrence Clay:* The raw clay was converted to the hydrogen form by reacting raw clay with hydrochloric acid of sufficient strength to replace all bases present and still be 0.05 *N* in HCl. After blunging with acid, the residue was washed twice by blunging with distilled water.

The excess water was removed by filtration after the final wash, and the moisture content of the residue was reduced to about 15% in plaster of Paris bats. It was stored in airtight cans. The time from starting to storing was twenty-one days. The H clay was stored at least fifty-five days before converting to another form.

To prepare the H clay for torsion tests, it was adjusted to the proper water content by pugging in a motor-driven meat grinder, stored for twenty-four hours, shredded in a meat grinder, and extruded from the deaired extrusion machine.[2] Extruded bars were

[7] Results on Lawrence clay were reported in part in the paper referred to in footnote 4.

TABLE III

EFFECT OF VARIOUS REPLACEABLE CATIONS ON LAWRENCE FIRE CLAY

Column (1), H_2O (%) by weight of dry body; (2), yield point (gm.-cm.); (3), maximum torque (gm.-cm.); (4), angle at maximum torque (degrees); (5), angle at ultimate failure (degrees).

Clay	(1)	(2)	(3)	(4)	(5)
Raw	19.2	472	1149	99	230
	20.2	396	932	100	226
	22.0	297	681	101	312
	22.9	257	582	101	328
Hydrogen	23.5	540	1044	97	248
	26.8	318	584	97	261
	27.8	281	506	97	237
100% lithium	17.5	615	1450	126	272
	19.2	417	976	132	303
	22.4	202	477	133	317
75% sodium	19.6	476	1160	127	332
	27.4	101	261	128	335
	29.4	78	190	128	276
	30.4	75	182	128	219
100% sodium	19.5	392	1011	131	322
	21.4	283	673	130	332
	24.0	140	374	131	336
125% sodium	18.5	403	1113	121	302
	22.0	263	745	121	325
	22.1	161	431	120	268
75% potassium	23.8	382	858	113	256
	24.9	327	710	113	252
	27.6	205	438	114	284
100% potassium	21.2	580	1414	108	165
	23.9	365	830	114	260
	26.5	234	517	116	222
125% potassium	23.2	492	1122	107	185
	25.2	345	779	110	197
	28.0	206	440	113	233
75% ammonium	23.3	524	1150	105	189
	25.4	379	870	108	242
	27.8	242	560	109	235
100% ammonium	21.9	700	1653	100	140
	25.4	377	837	109	222
	26.8	296	680	110	244
125% ammonium	22.1	695	1440	99	145
	25.9	330	750	108	247
	27.2	281	612	108	247
75% barium	22.8	334	734	118	232
	25.2	222	472	120	275
	28.2	135	295	120	295
100% barium	21.1	370	895	121	268
	21.1	366	893	121	260
	24.2	235	521	121	245
125% barium	20.2	458	1114	117	270
	22.1	361	825	117	302
	23.8	262	582	118	277
75% calcium	19.9	534	1210	107	258
	22.7	321	684	109	272
	24.7	213	462	110	289
101% calcium	19.2	550	1215	111	272
	22.8	260	552	112	330
	24.7	188	401	112	323
138% calcium	19.8	446	1010	108	288
	21.7	311	693	110	305
	24.0	201	438	111	337
167% calcium	20.1	413	943	111	298
	21.6	305	680	111	335
	24.2	199	443	112	324
75% magnesium	21.8	468	995	116	295
	26.3	197	428	115	324
	26.8	187	397	115	313
	31.6	73	185	115	360
100% magnesium	20.7	505	1141	117	313
	23.0	324	712	117	360
	25.9	148	382	118	317
	27.7	108	287	119	269
125% magnesium	21.0	464	1017	112	310
	24.1	271	607	112	291
	27.7	136	324	114	318
	28.9	108	271	114	322
75% aluminum	22.5	378	860	99	279
	24.7	266	570	99	340
	26.3	207	430	100	297
101% aluminum	22.9	350	863	99	259
	25.0	258	558	99	277
	26.3	198	410	100	339
138% aluminum	23.0	332	742	99	282
	24.4	261	560	99	305
	26.2	197	410	100	317
75% iron	20.3	810	1695	94	178
	23.4	448	898	96	272
	28.0	185	390	99	325
100% iron	20.4	743	1602	94	177
	23.5	417	856	95	284
	26.2	256	506	95	346
125% iron	21.4	608	1342	91	257
	25.5	316	622	90	265
	26.5	276	540	90	219

stored in a closed container but were tested within a few minutes after extrusion.

(*a*) *Na Lawrence Clay:* Sodium clay was formed from the hydrogen clay by dissolving a predetermined amount of NaOH in an amount of water about equal in weight to the clay. The clay and NaOH solution were mixed thoroughly and stored, with occasional stirring, for about ten days after which the water content was reduced to about 15% in plaster of Paris bats. The partly dried material was mixed thoroughly in a meat grinder and was stored in airtight cans until twenty-four hours before testing; the water content was then adjusted and the body was allowed to stand twenty-four hours in a water-saturated atmosphere. Bars were extruded and tested as in the case of H clay. The age of the body from the hydrogen form to extrusion was about eighty days.

(*b*) *Other Lawrence Clays:* Potassium, ammonium, lithium, magnesium, barium, calcium, aluminum, and iron clays were made and studied in the same manner as sodium clays. The other bodies were made in a manner similar to that described for preparation of Na clay; H clay was the starting point in each instance. KOH, NH_4OH, MgO, $Ba(OH)_2$, Li_2CO_3, $Ca(OH)_2$, $Al_2(SO_4)_3$, and $Fe(NO_3)_3$ were used to make the respective clays. The elapsed time in days of each clay, starting

with H clay, to extrusion of the body to be tested was 124, 102, 96, 123, 102, 113, 146, and 95, for K, NH_4, Mg, Ba, Li, Ca, Al, and Fe, respectively.

Raw clay bodies tested in torsion were tempered and aged three weeks before extrusion.

(*B*) *Kentucky Ball Clay:* The H clay was prepared in the same manner as the Lawrence H clay; drying in plaster of Paris was to about 20% of moisture; about twenty-five days were required. Base-treated samples were prepared by adding the calculated quantity of oxide or hydroxide in distilled water in amount equal to 150% of the weight of clay, stirring occasionally for ten days, and drying to 25% of moisture in plaster. Dried samples were stored in airtight containers until ready for testing. The age of the ball-clay bodies before testing in the torsion machine was as follows:

Clay	Age (days)	Reagent
Hydrogen	144*	HCl
Sodium	45†	NaOH
Magnesium	43†	MgO
Calcium	42†	$Ca(OH)_2$
Raw	1	

* Total time from addition of HCl to raw clay to torsion test.

† Total time from addition of reagent to H clay to torsion test.

(*C*) *Kentucky and Pennsylvania Flint Fire Clays:* The clays were ground in a ball mill to the following screen analyses:

Mesh size (Tyler)	Ky. (%)	Pa. (%)
+ 65	10.6	8.9
− 65+100	8.0	7.5
−100+150	10.1	7.3
−150+200	11.1	17.6
−200+325	10.7	8.4
−325	49.5	50.3

Hydrogen clay was made in the manner described for Lawrence clay. The water was reduced to about 40% by filtration in the washing operation, and the bodies were thoroughly mixed by a mechanical bread mixer (with wire mixer) and were transferred to glass jars. The H clay for torsion testing was dried to about 15% of moisture in plaster and was packed in airtight cans; ten days were required to prepare the H clay.

Base-treated bodies were prepared by adding the required amount of reagent and sufficient distilled water to make the weight of moisture 60% of that of air-dried clay. After standing for ten days, with occasional stirring, the bodies were dried to about 15% of moisture in plaster and were stored in sealed cans. All bodies were made to the desired moisture content twenty-four hours before testing in the torsion machine. The procedure described for Lawrence clay was employed. The aging time for the base-treated clays before testing was as follows:

Flint fireclay body	Age (days) Kentucky	Pennsylvania	Reagent
Hydrogen	53*	55*	HCl
Sodium	48†	60†	NaOH
Magnesium	47†	60†	MgO
Calcium	47†	60†	$Ca(OH)_2$

*Aging time from addition of HCl to raw clay to torsion test.

† Aging time from addition of hydroxide or oxide to H clay to torsion test.

A sample of raw Kentucky flint fire clay was ground finer and also tested in the torsion machine. Its screen analysis was as follows:

Mesh size (Tyler)	Re-ground (%)
+65	0.0
− 65+100	0.3
−100+150	6.4
−150+200	13.4
−200+325	12.7
−325	67.2

All raw flint clay bodies were aged one day before extruding the test bars.

(*D*) *Kaolin:* The raw kaolin was treated with HCl in the usual manner to form the H body, which was stored for about three weeks before testing. Base bodies were made by treating the H clay with the respective oxide or hydroxide for about two weeks, drying in plaster bats, storing, and adjusting the water content in the usual manner twenty-four hours before extrusion. The total time from H clay to base-treated clay was about six weeks.

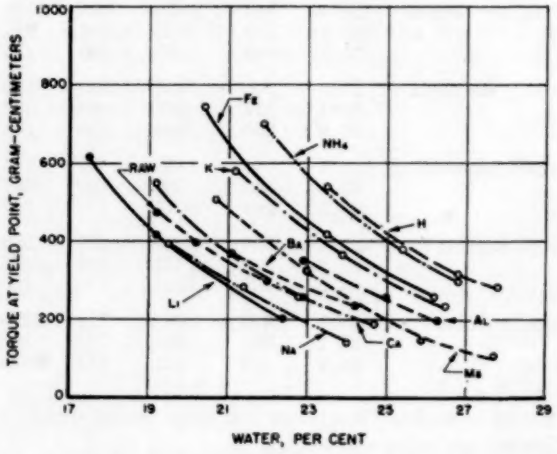

FIG. 1.—Effect of exchangeable bases on yield point of Lawrence fire clay.

(*E*) *Bentonite:* Raw bentonite was aged in the usual manner for six weeks before the torsion test. Hydrogen bentonite was made by treating the raw material with an amount of HCl equivalent to twice the base-exchange capacity. Washing was done with distilled water. The H body was aged by storing about six weeks after washing was completed before the torsion test.

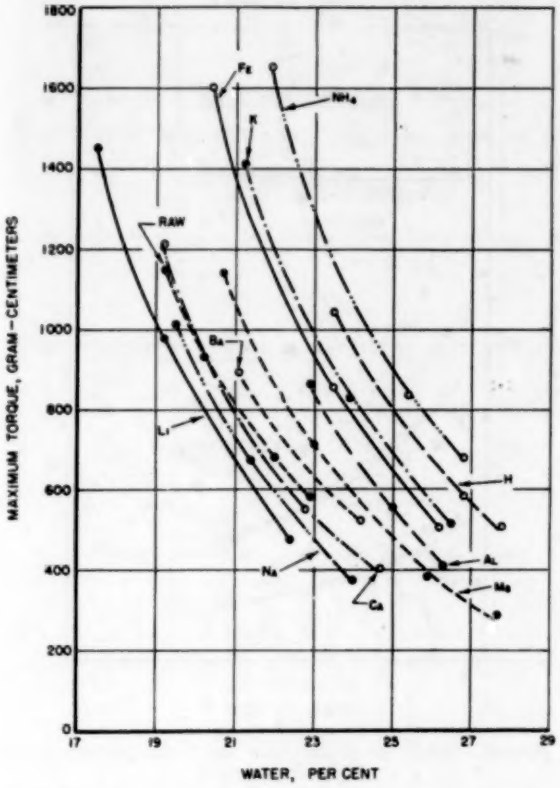

FIG. 2.—Effect of exchangeable bases on maximum torque of Lawrence fire clay.

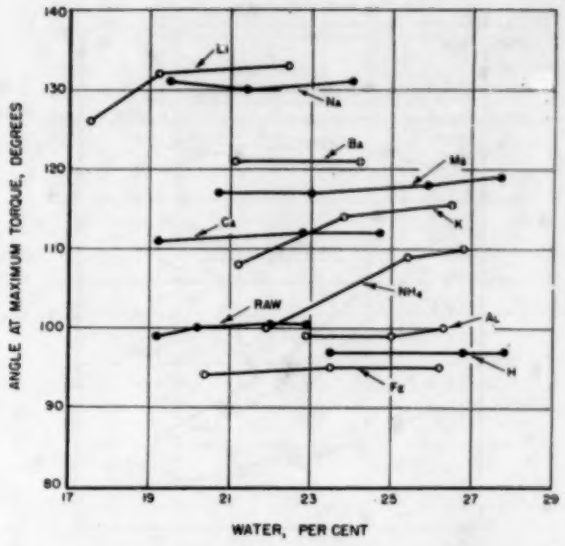

FIG. 3.—Effect of exchangeable bases on angle at maximum torque of Lawrence fire clay.

III. Results

(1) Lawrence Clay

Stress-strain data are given in Table III on raw, hydrogen, lithium, sodium, potassium, ammonium, barium, calcium, magnesium, aluminum, and iron forms at various water contents; in all forms, except raw, lithium and hydrogen with different percentages of base were added. Data on yield point, maximum torque, and angle at maximum torque for base-saturated bodies are given in Figs. 1, 2, and 3.

Figures 4, 5, 6, 7, and 8 give data on the effect of additions of bases corresponding to various percentages of base-exchange capacity for the sodium, potassium, ammonium, calcium, and aluminum forms, respectively. The figures, therefore, represent mono-, di-, and trivalent cations. In the case of Al^{+++}, however, replacement was effected with $Al_2(SO_4)_3$; the reaction product therefore was not H_2O as in the case of the mono- and di-valent forms.

(*A*) *Discussion:* The data in Table III and Figs. 1, 2, and 3 show the remarkable changes that may be made in the properties of clay by exchanging the bases on the particles. The order of increasing yield point for a given water content was Li, Na, raw, Ca, Ba, Mg, Al, K, Fe, NH_4, and H. The order of increasing maximum torque was Li, Na, Ca, raw, Ba, Mg, Al, Fe, K, H, and NH_4. The series of increasing angle at maximum torque was Fe, H, Al, raw, NH_4, Ca, K, Mg, Ba, Na, and Li. The Ca and raw clays fall close to each other in the yield-point and maximum-torque curves, and Table II shows that the raw clay is predominantly calcium in exchangeable-base characteristics.

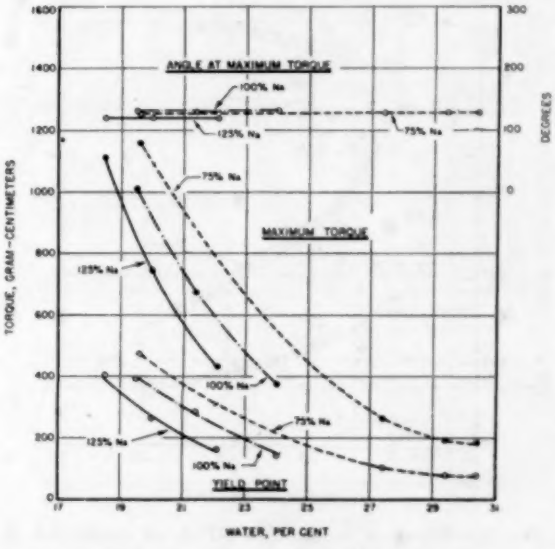

FIG. 4.—Effect of replaceable Na^+ on properties of H Lawrence clay.

The data in Figs. 4, 5, 6, 7, and 8 on the effect of additions of bases corresponding to various percentages of the base-exchange capacity show that not all the bases acted in a similar manner. The amount of water required to effect a given stiffness, i.e., maximum torque, in the Na clay decreased with the increasing percentage of NaOH added. The same was true of the

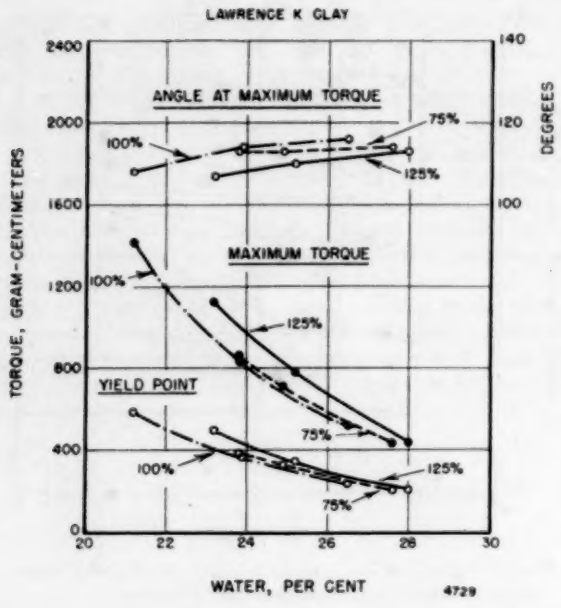

FIG. 5.—Effect of replaceable K^+ on properties of H Lawrence clay.

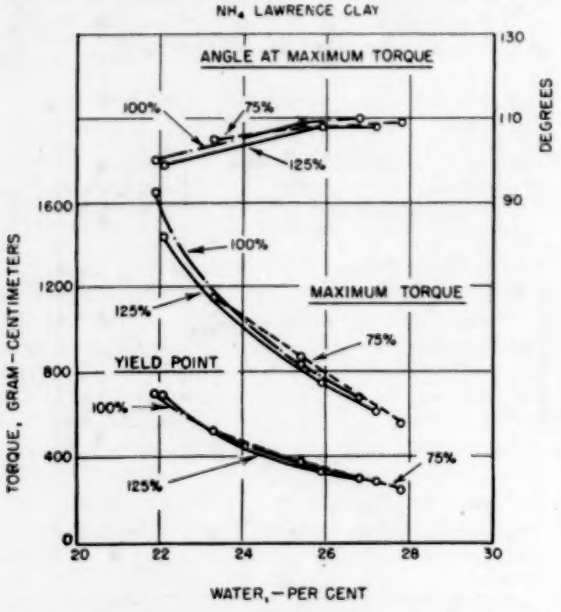

FIG. 6.—Effect of replaceable NH_4^+ on properties of H Lawrence clay.

yield point, which is a measure of the ability of a clay body to hold its shape, e.g., under sudden accelerations in handling. It is likewise a measure of the force that may be applied to a body and still have the latter return to its initial condition. The angle at which maximum torque occurs measures initial rupture of the body and is therefore a measure of extensibility; it was highest for 100% Na clay and lowest for 125%.

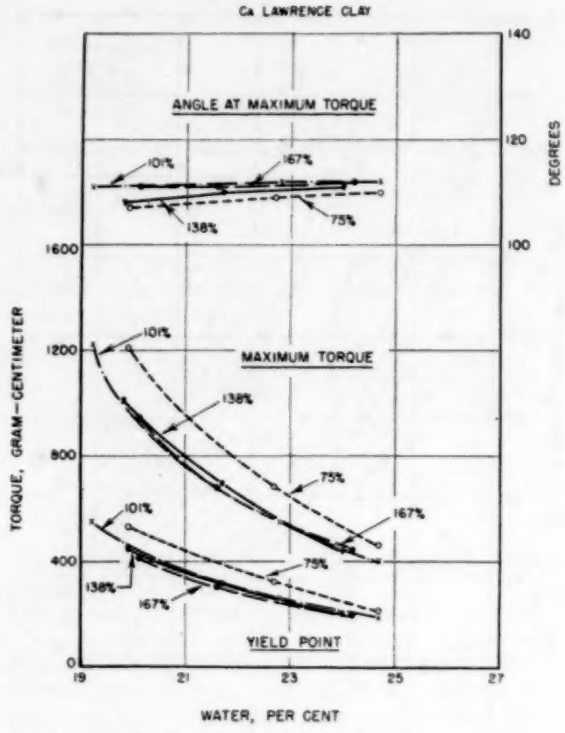

FIG. 7.—Effect of replaceable Ca^{++} on properties of H Lawrence clay.

For K clays, the lowest water content for a given yield point or maximum torque was with 100% clay and the highest was with 125%; the angle at which maximum torque occurred, however, fell in the same order as for Na clay.

Ammonium clay bodies had yield-point curves that nearly coincided, the 125% curve tending to be slightly lower than the others. The maximum-torque curve fell in the same order as for Na clay, but the values for 75, 100, and 125% NH_4 clays were much closer together than for the Na clays. The order of angle at maximum torque was substantially the same as for Na clay, although the 75 and 100% bodies crossed at low water content.

Calcium clays had yield points in the same order as Na clay with increasing percentages added, although the actual values were fairly close together. The water content for a given maximum torque was highest with the 75% Ca body. The lowest value was for 101%, but the 167% curve nearly coincided with it; in fact, the 138% curve was almost identically the same as the 101 and 167% curves. The lowest angle at maximum torque was with the 75% body and the highest for the 101%.

The yield-point curves of the Al clays were close; the 101% was slightly the highest and the 138% the lowest. The same order held for maximum torque, i.e., for a given stiffness, the least water was required for the 138% body and the most for the 101% body. Angles at maximum torque were virtually the same

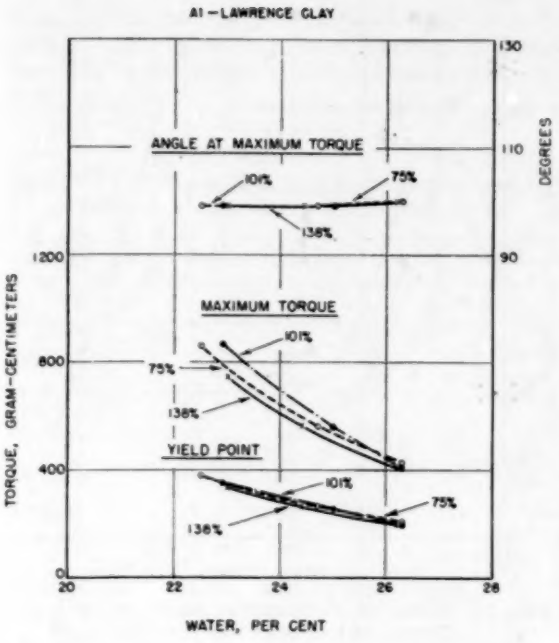

FIG. 8.—Effect of replaceable Al^{+++} on properties of H Lawrence clay.

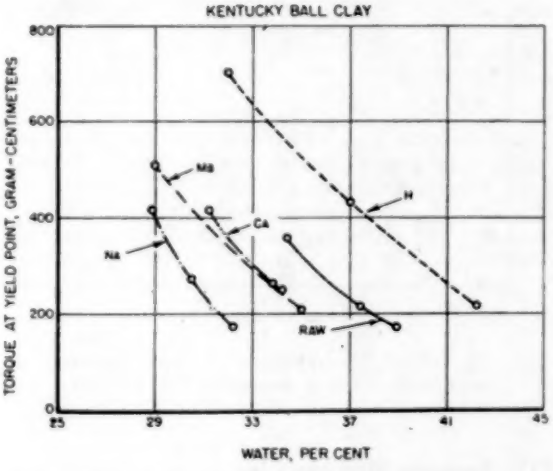

FIG. 9.—Effect of exchangeable bases on yield point of Kentucky ball clay.

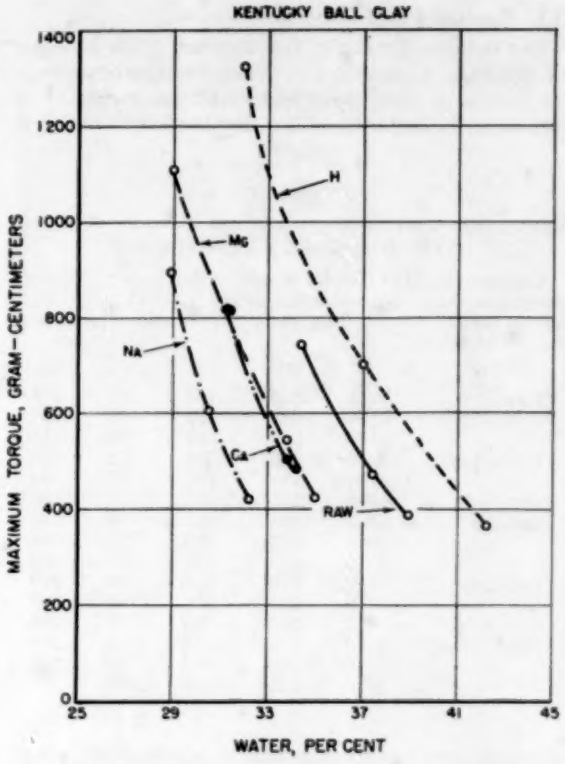

FIG. 10.—Effect of exchangeable bases on maximum torque of Kentucky ball clay.

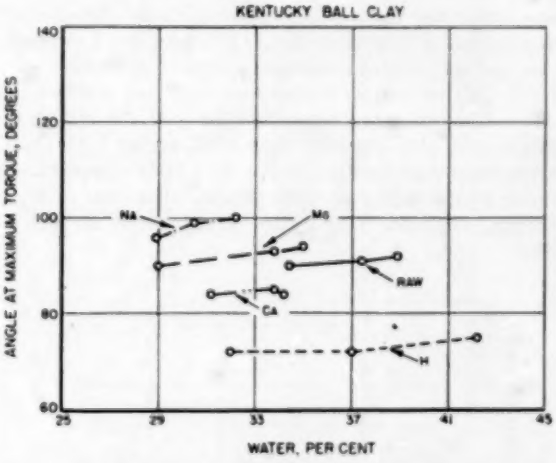

FIG. 11.—Effect of exchangeable bases on angle at maximum torque of Kentucky ball clay.

and were about the same as raw clay, whereas in all other bodies except hydrogen and iron the angle was considerably higher.

With Na clay, considered from the viewpoint of the water content required to produce a given stiffness as measured by maximum torque, less water was required as the Na increased from 75 to 125% of the base-exchange capacity. The same was true of NH_4 clay although the differences were much less. No definite conclusion can be drawn from the Ca bodies because the 101, 138, and 167% bodies had almost identical curves; considerably less water, however, was required for the 75% body, and thus it acted similarly to Na clay. The K clay was different from the Na clay and required the largest amount of water for the 125% body. The Al clay was different from Na, K, NH_4, or Ca clays because the lowest water content was required by the 138% body, the highest by the 101% body, and the 75% body was intermediate.

(2) Kentucky Ball Clay

The data on Kentucky ball clay are given in Table IV and Figs. 9, 10, and 11. Similar to Lawrence clay, the curves of yield point and maximum torque of H clay were the highest and Na clay the lowest with the

TABLE IV

EFFECT OF VARIOUS REPLACEABLE CATIONS ON KENTUCKY BALL CLAY, BASE-SATURATED

Column (1), H_2O (%) by weight of dry body; (2), yield point (gm.-cm.); (3), maximum torque (gm.-cm.); (4), angle at maximum torque (degrees); (5), angle at ultimate failure (degrees).

Clay	(1)	(2)	(3)	(4)	(5)
Raw	34.4	358	743	90	178
	37.4	215	472	91	230
	38.9	172	389	92	248
Hydrogen	32.0	702	1324	72	186
	37.0	432	702	72	269
	42.2	217	363	75	188
Sodium	28.9	418	895	96	256
	30.5	273	606	99	294
	32.2	175	421	100	302
Calcium	31.2	416	820	84	240
	33.8	265	503	85	295
	34.2	250	485	84	246
Magnesium	29.0	510	1110	90	209
	33.8	266	545	93	276
	35.0	210	425	94	251

divalent and raw bodies falling intermediate. Raw Kentucky ball clay was predominantly a Ca and Mg clay (see Table II). The angle at maximum torque was lowest for H clay and highest for Na clay. The angle at which maximum torque occurred, however, was lower for the various forms than in the similar base forms of Lawrence clay. Whereas raw Lawrence clay had an angle at maximum torque of approximately 100°, that of raw Kentucky ball clay was only about 90°. The maximum torques in the workable stiff-mud range were also generally somewhat higher with Lawrence than with the ball clay. As a body of low maximum torque will flow more readily than one of high torque, less force is necessary to extrude it through a die.

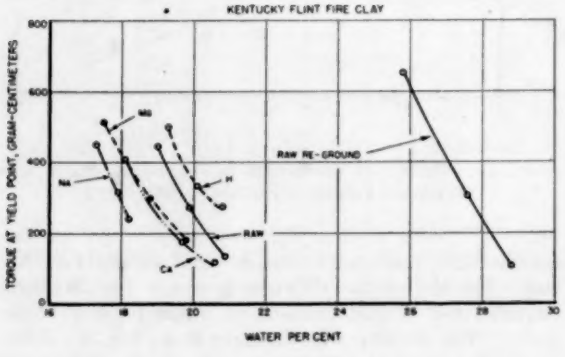

FIG. 12.—Effect of exchangeable bases on yield point of Kentucky flint fire clay.

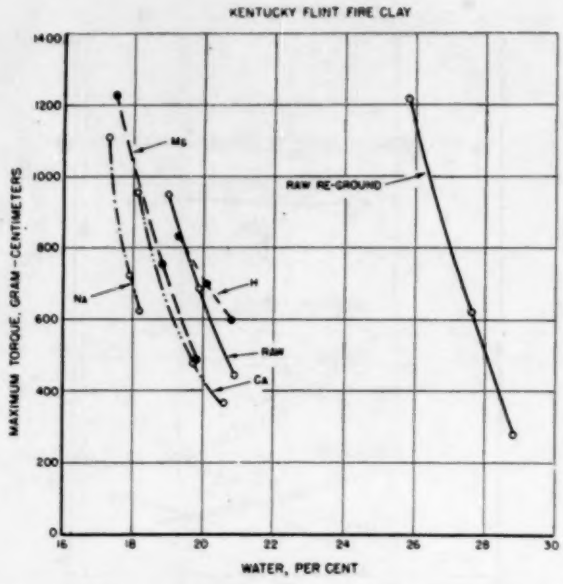

FIG. 13.—Effect of exchangeable bases on maximum torque of Kentucky flint fire clay.

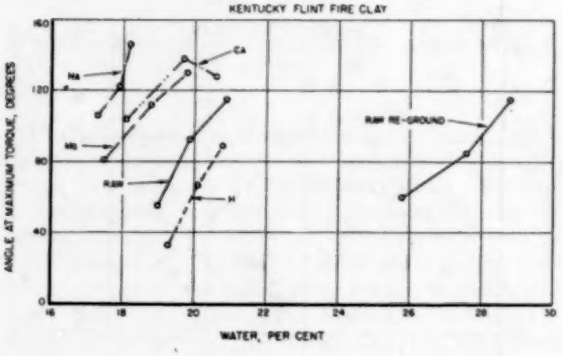

FIG. 14.—Effect of exchangeable bases on angle at maximum torque of Kentucky flint fire clay.

(3) Kentucky Flint Fire Clay

Data are given in Table V and in Figs. 12, 13, and 14. Results are given also for the raw re-ground clay. The most striking result is the larger amount of water required to put the re-ground body in a workable state. The order of yield point and maximum torque with different exchangeable bases is similar to that of the plastic clays already described. One of the striking results is the wide range of angle at maximum torque with changing water content. That of raw clay varied from 55° to 115°, whereas H clay had as low a value as 33°. Although the water content required for the re-ground body was much higher than for the clay as originally ground, the angles at maximum torque were quite similar. The fact should be stressed that the angle at maximum torque, which is a measure of ex-

tensibility as previously stated, varied widely with the different exchangeable base forms. Maximum torques tended to be somewhat higher than those for Lawrence clay.

TABLE V

EFFECT OF VARIOUS REPLACEABLE CATIONS ON KENTUCKY FLINT FIRE CLAY, BASE-SATURATED

Column (1), H_2O (%) by weight of dry body; (2), yield point (gm.-cm.); (3), maximum torque (gm.-cm.); (4), angle at maximum torque (degrees); (5), angle at ultimate failure (degrees).

Clay	(1)	(2)	(3)	(4)	(5)
Raw	19.0	442	949	55	60
	19.9	273	689	93	100
	20.9	136	445	115	130
Hydrogen	19.3	500	832	33	40
	20.1	334	700	67	80
	20.8	276	600	89	110
Sodium	17.3	450	1110	106	170
	17.9	316	725	122	200
	18.2	240	624	146	220
Calcium	18.1	409	955	104	140
	19.7	176	477	138	200
	20.6	118	366	128	180
Magnesium	17.5	513	1227	81	100
	18.8	298	753	112	160
	19.8	181	489	130	200
Re-ground raw	25.8	653	1216	60	60
	27.6	304	621	85	110
	28.8	107	280	115	160

TABLE VI

EFFECT OF VARIOUS REPLACEABLE CATIONS ON PENNSYLVANIA FLINT FIRE CLAY, BASE-SATURATED

Column (1), H_2O (%) by weight of dry body; (2), yield point (gm.-cm.); (3), maximum torque (gm.-cm.); (4), angle at maximum torque (degrees); (5), angle at ultimate failure (degrees).

Clay	(1)	(2)	(3)	(4)	(5)
Hydrogen	17.2	512	740	23	30
	18.7	296	457	31	40
	19.3	222	417	53	70
Sodium	14.7	679	1552	81	100
	16.6	245	656	135	200
	17.7	116	425	155	260
Calcium	16.2	417	949	67	90
	17.9	154	436	145	180
	19.5	72	250	161	230
Magnesium	15.8	515	1194	71	90
	17.1	298	693	87	120
	18.9	111	359	160	190

(4) Pennsylvania Flint Fire Clay

The data for this clay are given in Table VI and Figs. 15, 16, and 17. Particularly pertinent is the low angle at maximum torque of H clays and, as in the case of Kentucky flint clay, the wide spread with different water content. The yield points and maximum torques of the various base forms fell in the same order as the other clay bodies previously described.

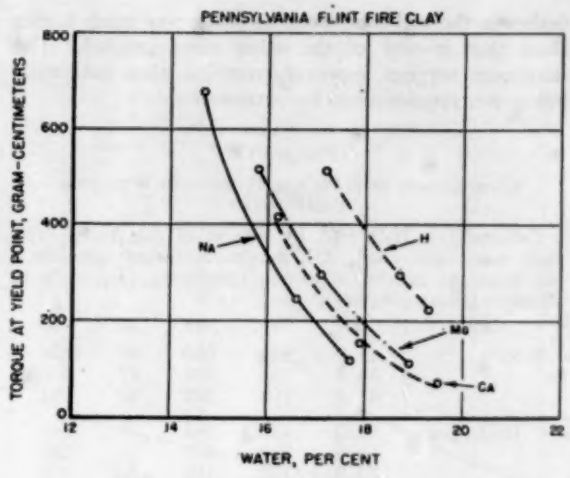

FIG. 15.—Effect of exchangeable bases on yield point of Pennsylvania flint fire clay.

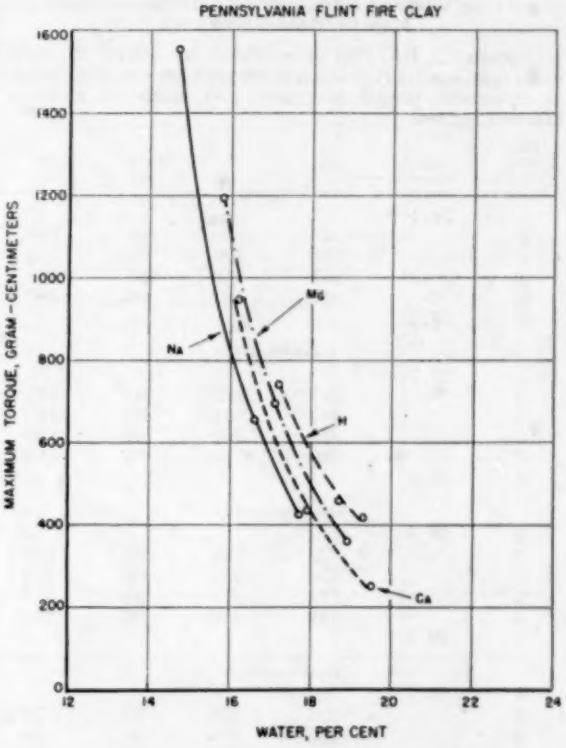

FIG. 16.—Effect of exchangeable bases on maximum torque of Pennsylvania flint fire clay.

(5) Wyoming Bentonite

Data are given in Table VII and Fig. 18 on raw and hydrogen forms of Wyoming bentonite. The most interesting result is the low values throughout. The angle at maximum torque of raw bentonite was lower than that of Lawrence or ball clay. The value of H bentonite likewise was considerably lower than for the raw form. The water content required to give

bodies in the stiff-mud working range was much higher than that in any of the other clays studied. The maximum torques, however, were low, thus indicating low power requirements for extrusion.

TABLE VII

COMPARISON OF RAW AND HYDROGEN WYOMING BENTONITES

Column (1), H_2O (%) by weight of dry body; (2), yield point (gm.-cm.); (3), maximum torque (gm.-cm.); (4), angle at maximum torque (degrees); (5), angle at ultimate failure (degrees).

Body	(1)	(2)	(3)	(4)	(5)
Raw	41.9	254	582	87	164
	54.8	151	348	87	207
	64.3	102	262	87	160
Hydrogen	54.0	410	745	59	148
	58.0	319	569	57	144
	73.3	102	195	55	169

TABLE VIII

EFFECT OF VARIOUS REPLACEABLE CATIONS ON GEORGIA KAOLIN, BASE-SATURATED

Column (1), H_2O (%) by weight of dry body; (2), yield point (gm.-cm.); (3), maximum torque (gm.-cm.); (4), angle at maximum torque (degrees); (5), angle at ultimate failure (degrees).

Bar No.	(1)	(2)	(3)	(4)	(5)
		Sodium clay			
1	29.1				
2		143	390	96	180
3		156	429	96	210
4		169	442	91	220
5		195	482	96	180
6	28.3				
		Calcium clay			
1	28.7				
2		247	572	84	145
3		247	611	80	145
4		273	702	80	105
5		299	780	76	110
6	27.9				
		Magnesium clay			
1	30.8				
2		78	299	96	190
3		104	351	93	230
4		117	377	94	250
5		143	416	93	250
6	29.9				
		Hydrogen clay			
1	29.7				
2		234	520	62	62
3		260	676	80	80
4		286	767	80	80
5		377	910	70	70
6	26.7				

(6) Georgia Kaolin

Results on various bodies of Georgia kaolin are only qualitative in value. The clay was extremely nonplastic, and bars made from it had little strength. In extruding, part of the water was squeezed out of the bars, and the water content varied from one end to the other of the extruded column. Data in Table VIII are given on sodium, calcium, magnesium, and hydrogen kaolin; Nos. 1 to 6 represent the order of the bars as cut from the column coming from the extrusion die. The water content varied, particularly in the case of H clay.

(7) Comparison of Data on Different Clays

The results in the foregoing tables and figures showed that the hydrogen and sodium clays were extremes in torsion properties. In the case of Lawrence clay, Li^+ was included in the study and Li clay was slightly lower in all values than Na clay; NH_4 clay was also slightly higher than H clay in maximum torque value, and Fe clay was slightly below H clay in angle at maximum torque. Comparative data are given in Figs. 19, 20, and 21 on the various clays studied except for Geor-

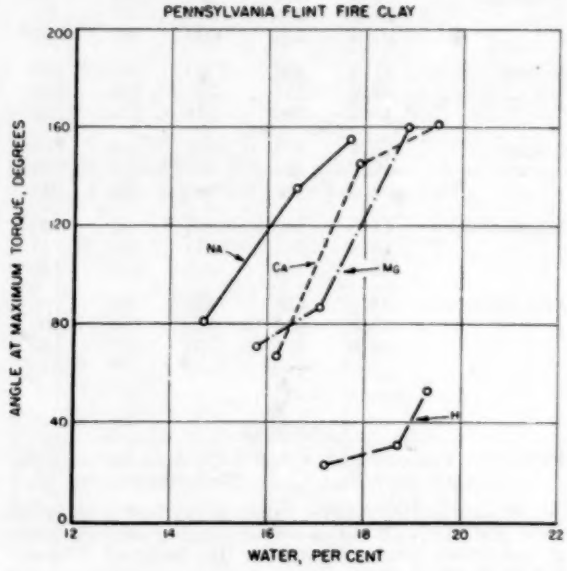

FIG. 17.—Effect of exchangeable bases on angle at maximum torque of Pennsylvania flint fire clay.

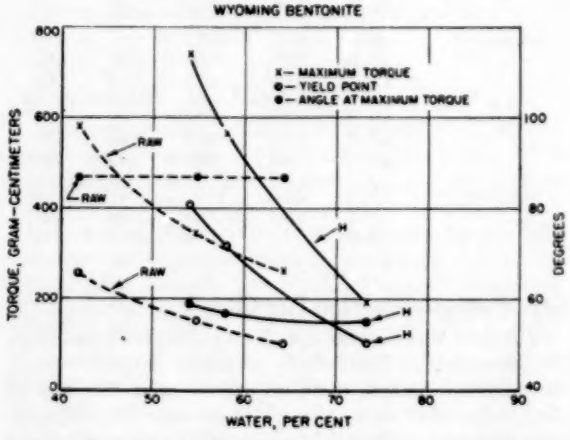

FIG. 18.—Yield point, maximum torque, and angle at maximum torque of raw and H forms of Wyoming bentonite.

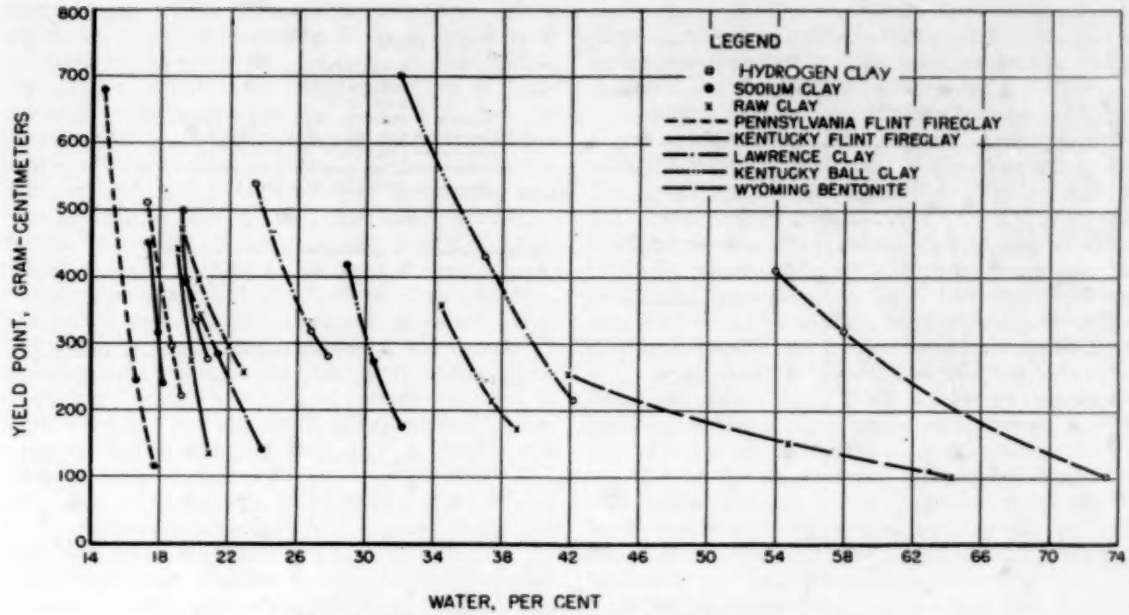

FIG. 19.—Yield points of various clays with different bases.

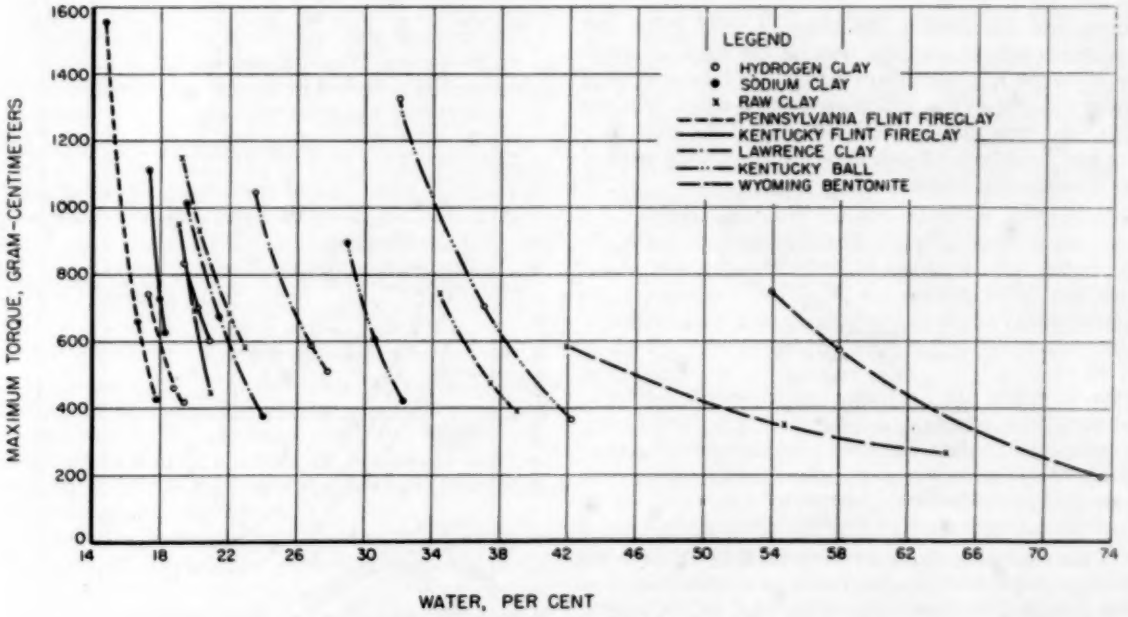

FIG. 20.—Maximum torque of various clays with different bases.

gia kaolin, whose values are considered too qualitative to be used for this purpose. Figure 19, giving yield-point results, shows that the range of water varied widely for bodies of stiff-mud workable consistencies. Although comparisons may be made at various yield-point values, a value near the middle of the range will be used. The order of increasing water contents for a yield point of 300 gm.-cm. is as follows: *flint fire clays*, Na Pa., Na Ky., H Pa., raw Ky., and H Ky.; *Lawrence fire clays*, Na, raw, and H; *ball clays*, Na Ky. and raw Ky.; raw bentonite (extrapolated); H Ky. ball; and H bentonite.

At a maximum torque of 600 gm.-cm., the order is as follows: *flint fire clays*, Na Pa., H Pa., Na Ky., raw Ky., and H Ky.; *Lawrence fire clays*, Na, raw, and H; *ball clays*, Na Ky., raw Ky., and H Ky.; *bentonites*, raw and H.

Angle at maximum torque values are somewhat harder to follow from the curves because of the wide variation in water content and the fact that families of

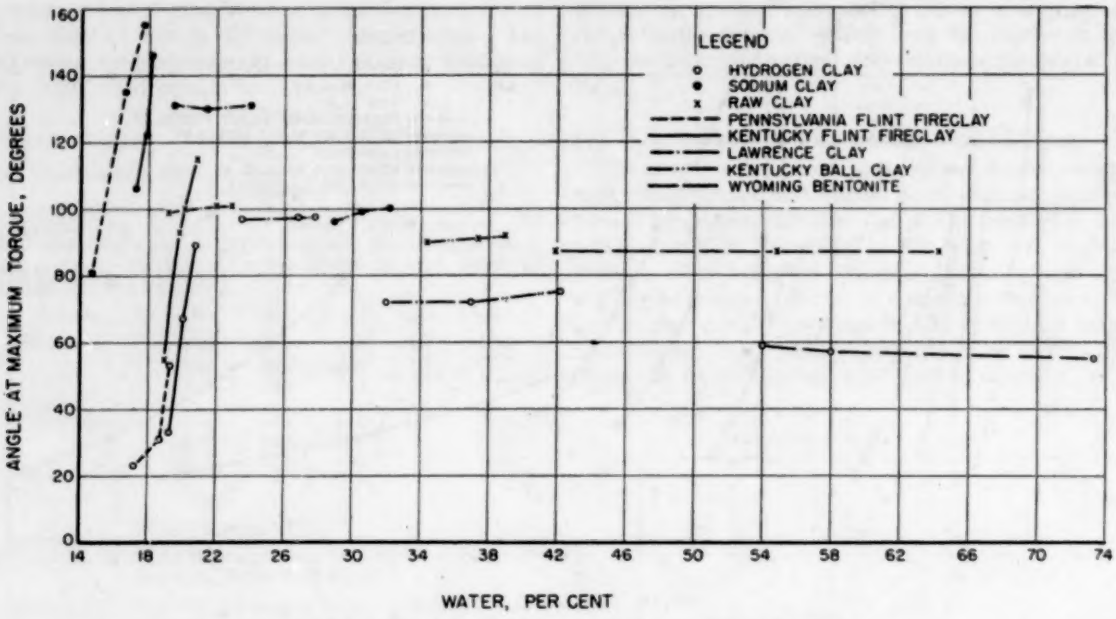

FIG. 21.—Angle at maximum torque of various clays with different bases.

curves are not formed like those of yield point and maximum torque, and also because the angle at maximum torque in plastic clays is virtually independent of water content in the stiff-mud working range, whereas this is not true for nonplastic bodies. If the intermediate water content is taken in each instance, the order of increasing angle follows:

Clays

Hydrogen { Pa. flint fire, bentonite, Ky. flint fire, Ky. ball

Raw { bentonite, Ky. ball, Ky. flint fire

Hydrogen Lawrence
Sodium Ky. ball
Raw Lawrence

Sodium { Ky. flint fire, Lawrence, Pa. flint fire

That enormous changes can be brought about in the torsion properties by exchangeable bases is evident from the foregoing tabulation and from Figs. 19, 20, and 21. For example, in considering extensibility (which is an important property), whereas H Pennsylvania flint clay had the lowest angle at maximum torque of all the various base forms of all the clays studied, the Na form of this clay had the highest value. The sodium forms of all clays were predominant in having high angles at maximum torque.

(8) Treatment of Clays Without Going Through Hydrogen Clay

Base-exchange reactions, as stated earlier in this discussion, may be considered to be chemical reactions following a modified mass-action law. It is desirable, for scientific studies, to convert the clay first to the hydrogen form so that when subsequent exchange is effected with a metallic cation, soluble-salt effects are eliminated. If, however, NaOH is added to the raw clay,

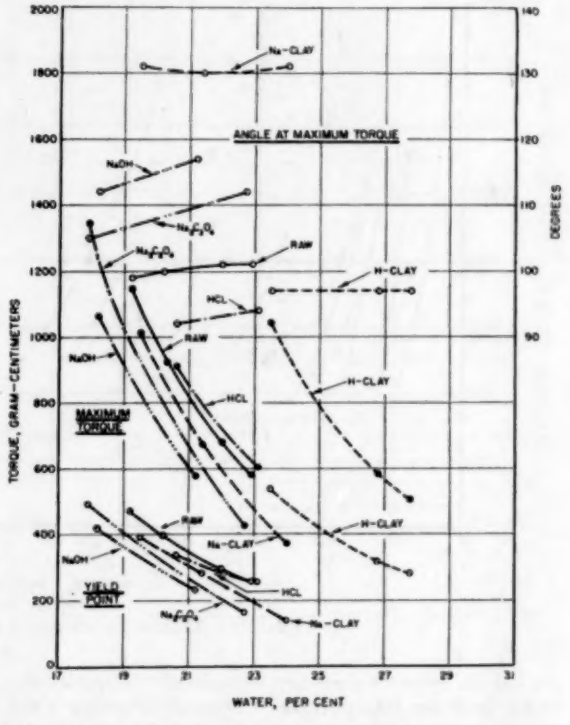

FIG. 22.—Effect of electrolyte additions on torsion properties of Lawrence fire clay.

base exchange will be effected at least in part. Washing to remove soluble salts and excess reagent will result in partial conversion of the clay to the hydrogen form. The addition of Na^+ to the extent of 100% of the base-exchange capacity to a raw clay does not produce the same effect as addition of the same quantity of Na^+ to a hydrogen form of clay. From a practical standpoint, however, the addition of electrolyte to the raw clay may be more desirable if the required effect can be secured.

Raw Lawrence clay was tempered with 20% of its weight of water containing electrolytes equivalent to various percentages of its base-exchange capacity. The bodies were pugged and stored for twenty days, and a sample was removed, extruded, and tested. A second sample was taken, and the water content measured; the sample was pugged, stored twenty-four hours, extruded, and tested in the usual manner. Data are given in Fig. 22 on raw clay, H clay, and Na clay made through H clay; raw clay treated with 100% of the base-exchange capacity of NaOH, with 100% of the base-exchange capacity of $Na_2C_2O_4$, and with 100% of the base-exchange capacity of HCl.

The information obtained is interesting and valuable because it shows that, when NaOH or $Na_2C_2O_4$ was added to raw clay in stoichiometric amounts equivalent to the base-exchange capacity, both a given yield point and given maximum torque resulted at a lower water content than with the 100% Na clay made from H clay. Addition of HCl, however, had only a minor effect on the properties. On the other hand, the angle at which maximum torque occurred was much higher with the 100% Na clay from H clay than either the NaOH or $Na_2C_2O_4$. These data may be used to get the property desired. A Na clay from H clay may be distorted more than a NaOH clay, but a NaOH clay of given water content should require less power in extrusion, and to get equivalent stiffness less water is required by the NaOH form.

IV. Discussion

No attempt will be made to discuss in detail all the findings of this investigation, but the reader will find applications to his particular problems. A few comments are necessary, however, to explain the fact that exchangeable bases exert so pronounced an effect on the properties of stiff-mud bodies.

A clay particle may be considered as being composed of a core (1), carrying on its surface basic and acidic groups of atoms or positive and negative charges or both (2). An atmosphere of adsorbed and unadsorbed ions (3) surrounds the particle, bringing the micelle into equilibrium with the surrounding or intermicellar solution (4). (The term "micelle" is used to designate the clay particle, its ionic atmosphere, and imbibed water, i.e., (1), (2), and (3).) The osmotically imbibed water is held by the ion atmosphere (3) in a layer of varying thickness and viscosity, depending on the thickness and density of the atmosphere.

Hydration of colloid particles depends on the nature of the adsorbed ion, and the water content increases with the degree of hydration of the adsorbed cation. The hydration of monovalent ions follows the series $Li^+ > Na^+ > K^+ > NH_4^+ > Rb^+ > Cs^+$. In base exchange, a monovalent cation replaces another cation of similar charge, whereas a divalent cation can displace two monovalent cations. Strongly hydrated ions, such as Li^+ and Na^+, have difficulty in getting close to the active clay particle because of the thickness of the water shell; K^+, which hydrates less, gets closer and is more firmly held. Further evidence that the colloidal properties of clays depend on the nature and extent of the water film or the layer of imbibed water is reflected in the phenomenon of coagulation and deflocculation of clays. In the coagulated condition, the layer of imbibed water is thin, and the clay particles therefore are close enough to attract each other molecularly. In the deflocculated condition, the clay particles are surrounded by imbibed water which lessens the effect of molecular attraction; this also explains the greater ease of deflocculating clays of the ball type, which imbibe large amounts of water, than kaolin and similar clay bodies.

Because the colloidal character of clays is governed in a large measure by the water film attached to the clay particles, because the nature and thickness of the water film is a function of the exchangeable bases present on the surface of the clay particles, and because the plasticity and workability of clays are governed by the colloidal nature of the clay particles, there is a rational explanation of why the exchangeable bases present have a pronounced effect on the torsion properties of clay bodies. Although the exchangeable ions may represent only a small percentage of the entire weight of the clay, the actual concentration on the surface may be high.

It should be pointed out that the length of time given in section II (1) (p. 40–42) for the preparation of the bodies was considerably longer than would be necessary in commercial work. In most instances, substantially all the bases may be exchanged in about twenty-four hours or less, although several days may be required to effect complete exchange.

From the work reported here, the conclusion may be drawn that the workability of clays may be changed and, to a large extent, governed by control of exchangeable bases.

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EFFECT OF EXCHANGEABLE BASES ON ABSORPTION AND TRANSVERSE STRENGTH OF CLAY BODIES*

By Robert P. Graham and John D. Sullivan

Abstract

The absorption and transverse strength of clay bodies, both in the fired and unfired state, are influenced greatly by the nature of the exchangeable bases present on the surface of the clay particles. Plastic clays with high exchange capacity are more affected than nonplastic clays, such as flint clays. Of the various common base forms studied, sodium-type clays in general require less water to give the same degree of stiffness, and their fired and unfired transverse strengths are high. Hydrogen clays require higher water content and have greater porosity and lower transverse strength. Data are given on a plastic fire clay, a ball clay, a bentonite, and two flint fire clays. All experiments made were on stiff-mud bodies.

I. Introduction

This paper is one in a series on the general study of base-exchange phenomena in clays. Former papers[1] dealt with stress-strain properties of clays and the effect of exchangeable bases on them.

II. Experimental Work

The experimental work reported here comprises the following topics: (1) the effect of exchangeable bases and moisture content on the dry or unfired absorption of Lawrence fire clay; (2) the unfired transverse-strength measurements on (*a*) raw, hydrogen, sodium, and calcium forms of Lawrence fire clay; (*b*) raw Lawrence fire clay with NaOH or HCl added; (*c*) raw, hydrogen, sodium, and calcium forms of Kentucky ball clay; (*d*) raw, hydrogen, sodium, and calcium forms of Pennsylvania flint fire clay; (*e*) raw, hydrogen, sodium, and calcium forms of Kentucky flint fire clay; and (*f*) raw and hydrogen forms of Wyoming bentonite; (3) unfired absorption on all bodies in (2); (4) fired absorption on bodies 2(*a*), 2(*b*), 2(*c*), and 2(*d*); and (5) fired transverse strength on bodies 2(*a*), 2(*b*), 2(*c*), and 2(*d*).

The terminology is the same as that used in previous papers of this series. Raw clays refer to the materials with no base exchange effected and are identified by chemical and base-exchange analyses given in Tables I, IV, and V of the first paper[2] of this series. Hydrogen clay refers to the material in which substantially all of the exchangeable bases are replaced with H^+. Sodium clay refers to the product made by treating H clay with Na^+, as NaOH, equivalent to the base-exchange capacity of the clay. Other terms have corresponding meanings. If H clay is treated with an oxide or hydroxide to effect exchange, the reaction product is H_2O and the soluble salt effects are eliminated. Raw clay plus 100% NaOH indicates a raw clay to which NaOH equivalent to its base-exchange capacity was added.

(1) Effect of Exchangeable Bases on Unfired Absorption of Lawrence Fire Clay

Tests were made on aged specimens of eight base-saturated bodies. Tests in all cases were made on $^1/_2$-inch diameter bars extruded from the deairing extrusion machine.[1(c)] The age of the bodies at the time of extrusion was the same as that given for similar bodies in the paper of this series on the torsion properties of base-treated clays.[1(c)] The bars, which had been in storage about six months after extrusion, were dried overnight at 105°C. before testing. Absorption was determined by the kerosene immersion method, but values are reported as the water equivalent.

The data in Fig. 1 show the remarkable effect of exchangeable bases on dry or unfired absorption. All bodies were in the plastic or so-called workable stiff-mud range, and the three water contents represented moderately dry, medium, and fairly wet or soft bodies. Changes in water content to a much greater extent would have put the bodies outside the workable range. Whereas the absorption of sodium clay varied from 11.0 to 11.7% by changing the water content from 19.5 to 24.0%, the absorption range of all bodies varied from as low as 10.3% for Li clay to 16.9% for NH_4 clay.

(2) Preparation of Bodies for Transverse-Strength and Fired-Absorption Experiments

The bodies were made with a single water content selected from previous work to give bars of a maximum torque of about 800 gm.-cm. in the torsion machine used in the work at Battelle. This would insure bars of approximately equal or uniform stiffness.

The Lawrence fire clay, Kentucky ball clay, and bentonite were used without fine grinding. The materials were approximately 8-mesh or finer in size, and they all slaked on addition of water. The flint

* Received October 6, 1939. Work done under Battelle Research Associate Fund.

[1] (*a*) R. P. Graham and J. D. Sullivan, "Improved Machine Shows Different Forms of Failure of Clay Bodies in Torsion," *Bull. Amer. Ceram. Soc.*, **18** [3] 97–100 (1939).

(*b*) R. P. Graham and J. D. Sullivan, "Workability of Clays," *Jour. Amer. Ceram. Soc.*, **22** [5] 152–56 (1939).

(*c*) J. D. Sullivan and R. P. Graham, "Effect of Exchangeable Bases on Torsion Properties of Clays," *ibid.*, this issue, p. 39.

[2] R. P. Graham and J. D. Sullivan, "Critical Study of Methods of Determining Exchangeable Bases in Clays," *Jour. Amer. Ceram. Soc.*, **21** [5] 176–83 (1938).

clays were ground before use to the following screen analyses:

Size (Tyler mesh)	Pa. flint (%)	Ky. flint (%)
+65	8.9	10.6
−65 + 100	7.5	8.0
−100 + 150	7.3	10.1
−150 + 200	17.6	11.1
−200 + 325	8.4	10.7
−325	50.3	49.5

The general procedure in all cases for raw clay bodies was to mix thoroughly with the desired amount of distilled water, run through a meat-grinder shredder three times, store in glass jars to age, and again shred and extrude. Hydrogen clays were prepared from raw clays by treating with dilute HCl as described in earlier papers. The H clay, like the raw clays, was stored to age, shredded, and extruded. Base-treated clays were made from H clay by adding the respective cation in the form of oxide or hydroxide in amount equivalent to the base-exchange capacity. The base-treated clays were aged, shredded, and extruded.

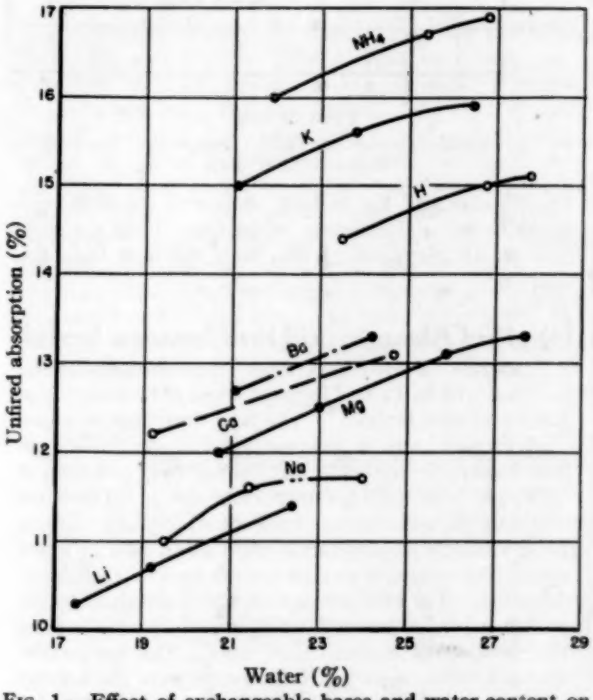

FIG. 1.—Effect of exchangeable bases and water content on unfired absorption of Lawrence fire clay.

All extruded bars, except bentonite, were dried for two days under a moist towel, in open air at least a week, and stored in a drawer until ready for testing, and all bars were dried overnight at 105°C. before testing. Bentonite bars were dried under a moist cloth for two weeks; they were turned several times a day to prevent warpage, then air-dried, and finally dried overnight at 105°C.

Specific aging information is given in Table I. Column (1) lists the form of clay; (2) the age of raw clay from addition of water to extrusion; (3) the time elapsed from addition of HCl to raw clay to storage; with bentonite to the addition of the desired base; (4) age of hydrogen clay after adjustment of water content to extrusion; and (5) time from the addition of the desired base to H clay to the extrusion of the respective base form.

TABLE I

AGING DATA ON VARIOUS CLAY BODIES

Column (1), type of clay; (2), age (days); (3), time from raw clay to H clay, including storage (days); (4), H clays aged before extrusion (days); (5), time from addition of base of H clay to extrusion (days).

(1)		(2)	(3)	(4)	(5)
Lawrence	raw	20			
	hydrogen		20§	21†	
	sodium				41
	calcium				35
Raw clay	+100% NaOH	21			
	+100% HCl	33			
Ky. ball	raw	33			
	hydrogen		25*	39†	
	sodium				41*
	calcium				37
Pa. flint fire	raw	35			
	hydrogen		10‡	42†	
	sodium				22
	calcium				46
Ky. flint fire	raw	28			
	hydrogen		10‡	40†	
	sodium				48
	calcium				46
Wyo. bentonite	raw	44			
	hydrogen		22	23	

* Hydrogen body stored at 20% H_2O for about 10 months before using.

† After adjustment of water content.

‡ Stored about 6 months with about 40% water content.

§ Hydrogen body stored at about 5% water for about 10 months.

(3) Unfired Transverse Strength and Absorption

Measurements were made on the dried bodies, using a $1^1/_2$-inch span. Ten bars of each body, except the bentonites, were broken; only four bentonites were used. Table II includes data on unfired absorption and unfired transverse strength.

The reason that such small test bars and a short span were used was to avoid the necessity of preparing and storing large quantities of base-treated clays. Considerable time and effort were required to make the bars and to adjust them to the exact water contents desired. All bars were tested under the same conditions, and the results on all bodies are comparable.

The data show that there was a decided tendency for bodies of low absorption to have high dry transverse strength and for bodies of high absorption to have low strength. The H clays were uniformly low in strength and the Na bodies were uniformly high. In every case except the Pennsylvania flint fire clay,

TABLE II

EFFECT OF EXCHANGEABLE BASES ON THE DRY TRANSVERSE STRENGTH OF VARIOUS CLAYS

Column (1), H_2O (%) by weight of dry body; (2), unfired absorption (%); (3), transverse strength (lb. per sq. in.); (4), transverse strength (avg. deviation (%) from mean).

Clay	(1)	(2)	(3)	(4)
Lawrence plastic				
Sodium	20.4	12.1	1970	3.8
Calcium	21.8	13.2	1260	4.2
Hydrogen	26.6	15.2	1020	3.6
Raw	23.2	13.8	970	2.5
Raw + 100% {NaOH*	20.6	11.9	1560	4.2
Raw + 100% {HCl*	22.8	13.9	990	6.0
Ky. ball				
Sodium	29.3	15.1	2610	4.1
Calcium	34.3	19.4	1360	3.2
Hydrogen	35.6	21.9	870	7.2
Raw	35.4	16.9	1240	5.2
Wyo. bentonite				
Hydrogen	41.0		5090	2.6
Raw	35.5		5560	3.0
Ky. flint				
Sodium	18.4	11.9	1150	2.5
Calcium	18.4	12.3	1060	4.8
Hydrogen	18.4	13.7	660	3.6
Raw	19.7	14.3	570	5.1
Pa. flint				
Sodium	15.6	10.9	860	4.5
Calcium	18.3	11.4	970	2.4
Hydrogen	17.9	12.7	540	3.3
Raw	15.9	11.5	550	1.5

* Reagent equivalent to the base-exchange capacity.

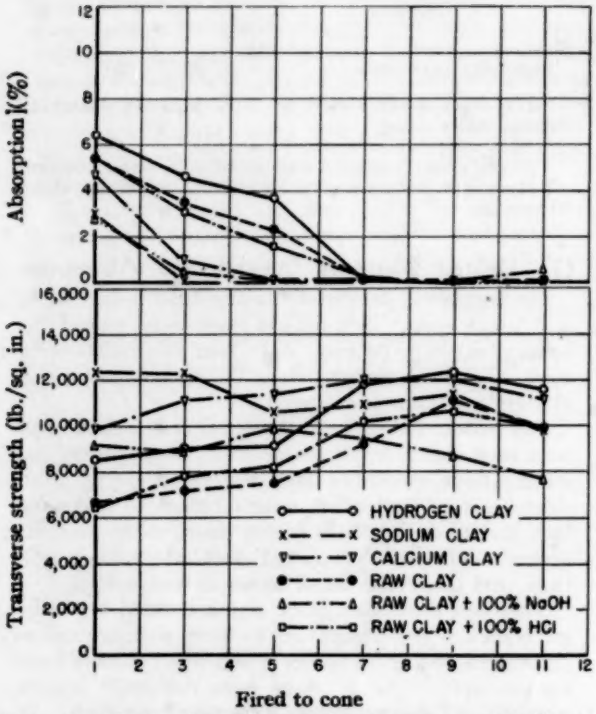

FIG. 2.—Fired absorption and transverse strength of Lawrence clay bodies.

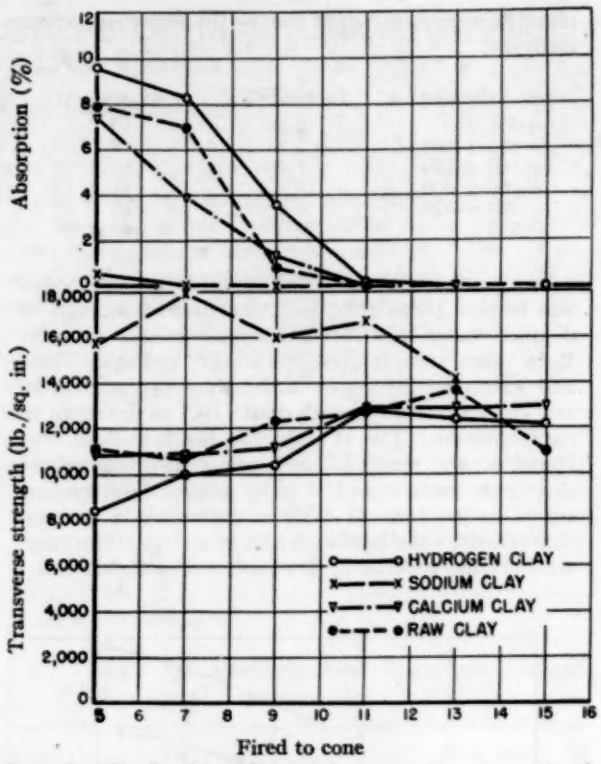

FIG. 3.—Fired absorption and transverse strength of Kentucky ball clay.

the Na clay had the highest transverse strength, and its value was only slightly below that of the Ca clay. The plastic clays, as a class, were stronger than the flint clays.

(4) Fired Absorption and Fired Transverse Strength

Properties of fired bars were determined on all the bodies tested in Table II except those of bentonite and Kentucky flint fire clay. The bars were fired in a gas-fired furnace with a temperature rise of 120°F. per hour to three cones below the desired cone and then at 50°F. per hour until the cone came down. The flame was shut off, and the bars were cooled in place. Transverse strength measurements were made on a $1^1/_2$-inch span. Ten or twelve specimens were used for each determination. The fired absorption was determined by the water-immersion method, using broken specimens from the fired transverse-strength tests. The transverse-strength values reported in the tables were the average of all the specimens tested. The practice, often followed, of discarding values that deviate more than 15% from the mean was not used. Weighing was to the nearest 0.01 gram.

Bars were fired to the following cones:

Clay	Cones
Lawrence	1, 3, 5, 7, 9, 11
Ky. ball	5, 7, 9, 11, 13, 15
Pa. flint	11, 13, 15, 17

(A) Lawrence Clay: Data are given in Table III and Fig. 2. The absorption of hydrogen clay up to

cone 7 was greater than that of raw clay, but that of the other bodies was lower. The curve of raw clay plus 100% HCl was only slightly below that of raw clay alone. The values above cone 7 were about the same until overfiring occurred. The transverse strength of raw clay was predominantly lower than that of other bodies up to cone 7, and in no instance was it as high as the Na or Ca forms. The curve of raw clay plus 100% HCl followed quite closely that of raw clay alone.

III. Discussion

All of the test bars were made of finely divided particles and were straight bodies with no grog additions. Inasmuch as the purpose of this investigation was to determine the effect of exchangeable bases on various typical clays, simple bodies were used. The conclusions to be drawn from this study, however, obviously give information that is applicable to bodies made by blending clays and those with grog or calcine additions.

TABLE III

FIRED ABSORPTION AND TRANSVERSE STRENGTH OF LAWRENCE CLAY BODIES

Column (1), avg. fired absorption (%); (2), transverse strength (lb. per sq. in.); (3), transverse strength (avg. deviation (%) from mean).

Body	Cone 1			Cone 3			Cone 5			Cone 7			Cone 9			Cone 11		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Hydrogen	6.4	8,500	6.7	4.6	9,000	9.8	3.7	9,100	10.7	0.1	11,800	11.2	0.0	12,300	11.3	0.0	11,600	6.8
Sodium	3.0	12,400	5.9	0.1	12,300	8.3	0.0	10,600	7.9	0.0	10,900	7.6	0.0	11,400	8.3	0.1	9,800	6.9
Calcium	4.7	9,900	7.4	1.0	11,100	9.1	0.1	11,400	7.3	0.1	12,000	10.4	0.0	12,000	11.7	0.1	11,200	7.3
Raw	5.4	6,700	5.5	3.5	7,200	3.2	2.3	7,500	11.3	0.2	9,200	10.9	0.1	11,100	4.7	0.1	9,900	4.9
Raw + 100% NaOH*	2.8	9,200	8.6	0.5	8,900	5.2	0.1	9,900	11.0	0.1	9,400	5.6	0.1	8,700	10.9	0.5	7,700	8.7
Raw + 100% HCl*	5.4	6,400	3.6	3.1	7,800	11.6	1.6	8,200	7.1	0.3	10,200	8.3	0.1	10,600	10.7	0.0	9,900	8.4

* Reagent equivalent to the base-exchange capacity.

(*B*) *Kentucky Ball Clay:* These data are given in Table IV and Fig. 3. The sodium clay was predominant in having high transverse strength, whereas the hydrogen body had the lowest. The reverse was true of the fired absorption. The raw and calcium bodies had similar properties throughout, but (as was shown in an earlier paper)[2] this might be expected because the raw ball clay was essentially a Ca clay with a substantial amount of exchangeable Mg^{++} also present. The Na clay at cone 15 was too badly distorted to make transverse-strength measurements, and the bars had a black core. The raw clay dropped in strength from cone 13 to 15, probably indicating overfiring.

Specific studies on various batches, including coarse calcines and coarse flint clay, would be desirable.

Fundamentally, exchangeable bases have a pronounced effect on the water content required to produce a body of given stiffness. The exchangeable bases present on the surface govern, in a large measure, the colloidal character of the clay, which in turn is a controlling factor of the workable characteristics of the clay body. Those that required a low moisture content had lower unfired absorption than those requiring high moisture.

Considering the Na, Ca, and H forms, which might be termed "pure" clays because the soluble salts for the most part were removed, with the four

TABLE IV

AVERAGE FIRED ABSORPTION AND TRANSVERSE STRENGTH OF KENTUCKY BALL CLAY BODIES

Column (1), avg. fired absorption (%); (2) transverse strength (lb. per sq. in.); (3), avg. deviation (%) from mean.

Body	Cone 5			Cone 7			Cone 9			Cone 11			Cone 13			Cone 15		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Hydrogen	9.6	8,400	14.3	8.3	10,000	7.7	3.6	10,400	7.7	0.2	12,800	11.0	0.0	12,400	8.7	0.0	12,200	9.3
Sodium	0.5	15,700	8.2	0.1	17,900	6.9	0.0	16,000	10.1	0.0	16,700	11.9	0.0	14,200	7.4			
Calcium	7.4	10,900	6.0	3.9	10,800	8.6	1.3	11,200	12.4	0.0	12,900	16.6	0.0	12,900	17.8	0.0	13,000	8.5
Raw	7.9	11,100	10.8	7.0	10,700	11.8	0.8	12,300	8.5	0.0	12,700	13.6	0.0	13,700	10.1	0.0	11,000	6.0

(*C*) *Pennsylvania Flint Fire Clay:* Table V and Fig. 4 contain the results. None of the bodies reached zero absorption at cone 17 although the Ca form most nearly approached it. Hydrogen clay had the highest absorption and the lowest transverse strength. The raw clay was the strongest. The transverse strengths were appreciably lower than those of the Lawrence or the Kentucky ball clays, and in general they did not increase much with higher firing temperatures. The effect of the exchangeable bases likewise was not so pronounced as in the plastic bodies.

bodies on which data are available, viz., Lawrence, ball, and the two flint clays, Na clay in every instance had the lowest unfired absorption, and H clay the highest. Hydrogen clays required the most moisture to give bodies of a definite stiffness, and Na clays the least. The unfired transverse strength fell in the same order as unfired absorption in every case except in Pennsylvania flint clay in which the Ca clay was slightly stronger than Na clay, but in this case the unfired absorptions were quite close.

The fired absorption, likewise, fits into a regular order

TABLE V

FIRED ABSORPTION AND TRANSVERSE STRENGTH OF PENNSYLVANIA FLINT FIRECLAY BODIES

Column (1), avg. fired absorption (%); (2), transverse strength (lb. per sq. in.); (3) transverse strength (avg. deviation (%) from mean).

Body	Cone 11			Cone 13			Cone 15			Cone 17		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Hydrogen	6.4	5300	3.3	4.9	5600	3.7	4.6	5800	7.0	3.6	6600	8.2
Sodium	4.5	6200	5.4	3.4	6100	8.2	3.6	6900	10.4	2.8	8100	9.2
Calcium	4.3	5800	6.3	2.9	6300	6.1	2.9	6700	7.1	2.1	7600	11.6
Raw	5.9	6200	5.4	4.8	7100	5.2	3.9	7800	7.1	3.5	8800	8.4

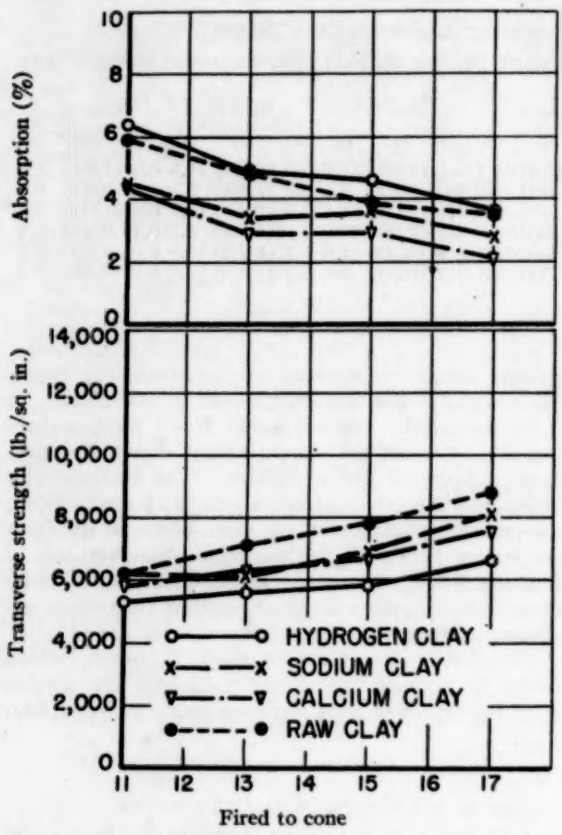

FIG. 4.—Fired absorption and transverse strength of Pennsylvania flint fire clay.

(see Figs. 2, 3, and 4). The fired absorption of the Lawrence bodies at cone 1 fell in the order of Na, Ca, and H clays or the same order as the unfired absorption. The same is true of the Kentucky ball clay at cone 5.

The degree of firing required to approach zero absorption likewise was a function of the unfired absorption as may be seen from an examination of the curves in the figures.

The fired transverse strength was a function of fired absorption until overfiring occurred; the fired strengths of the Na clays were predominantly high and those of the H clays, low. The Na, Ca, H, and raw forms of Kentucky ball clay all had the same P.C.E. value, viz., cone 32.

These studies show the pronounced effect of exchangeable bases on the absorption and transverse strengths of clay bodies, both in the fired and unfired state. They also show that the more plastic bodies with higher exchange capacity are influenced more than the clays of low exchange capacity as exemplified by flint fire clays. The results reported substantiate the conclusion that the properties of clays may be changed and, to a large degree, governed by control of exchangeable bases.

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CORRECTION FOR JANUARY JOURNAL PAPER

In the paper by F. R. Bacon and O. G. Burch, "Effect of Time and Temperature on Accelerated Chemical Durability Tests Made on Commercial Glass Bottles," *Jour. Amer. Ceram. Soc.*, **23** [1] 1–9 (1940), on page 9, section IV, the authors make the following statement:

"(5) There is no absolute relation between the tendency of a bottle to form flakes when filled with distilled water and the amount of alkali leached from the glass surface by distilled water; this holds for all glass compositions."

Mr. Burch states that the authors desired this paragraph to read as follows:

"(5) There is no absolute relation that holds for all glass compositions between the tendency of a bottle to form flakes when filled with distilled water and the amount of alkali leached from the glass surface by distilled water."

EFFECT OF EXCHANGEABLE BASES ON DRYING OF CLAY BODIES*

By John D. Sullivan and Robert P. Graham

Abstract

Studies were made at 100°F. and 50% relative humidity, 150°F. and 50% humidity, and 175°F. and 15% humidity to determine the effect of exchangeable bases present on the surface of the clay particles on drying rates. Drying may be considered to take place in two stages which are characterized by different rates. The first is rapid and is accompanied by shrinkage of the body, whereas the second is considerably slower and the shrinkage is slight. The drying rates of the base-saturated bodies studied were nearly the same in the first stage, but in the second pronounced differences resulted. Sodium clays dried much more slowly than the other bodies investigated. At 175°F. and 15% humidity, H clay dried the most rapidly. A rational explanation of the phenomena, based on the colloidal nature of the clay particle and on the unfired absorption of the bodies, is given.

I. Introduction

This paper, another in the series on the effect of exchangeable bases on the properties of clays, considers the drying of stiff-mud bodies. Previous papers showed that with different exchangeable bases on the surface of the clay particles, different water contents were required to give bodies of definite stiffness[1] and that the dry or unfired absorption of bodies extruded at a given stiffness likewise varied with the base form of the clay.[2]

Morgan and Hursh[3] discussed conditions governing the diffusion of water in clays and concluded that in general the drying takes place in two stages. The initial stage comprises drying with the rate decreasing slowly and approximately linearly until shrinkage at the surface is complete. The second stage is slower than the first, and the rate drops off rapidly owing to the increased resistance to diffusion. The point separating the two branches of the rate curve has been termed the "critical point" or "surface shrinkage limit."

In drying a clay body, interstitial moisture as well as adsorbed moisture must be considered. As pointed out in previous papers,[4] the adsorbed water film depends on the nature and degree of hydration of cations on the surface.

This paper reports experimental work on drying bodies containing different exchangeable cations.

II. Experimental Work

The work was done on Lawrence fire clay on which the chemical and exchangeable base analyses were given in a former paper.[5] Tests were made at temperatures of 100°, 150°, and 175° F., with respective relative humidities of 50, 50, and 15%.

(1) Preparation of Bodies

Bodies were made of raw, hydrogen, calcium, and sodium clays. The same terminology is used as in the earlier papers, and all base-treated bodies were base-saturated. Calcium and Na clays were made from H clay, which previously had been prepared by acid treatment of the raw clay and had been stored at about 5% of moisture for several months. Raw- and H-clay bodies for the tests were prepared by adding the required water to the respective bodies, passing them three times through a meat-grinder shredder, and storing to age for 15 days. The clays were then shredded and extruded. The Na and Ca bodies were prepared in an identical manner by adding to H clay the base-exchange equivalent of Na^+ and Ca^{++} as NaOH and $Ca(OH)_2$, respectively, dissolved in water. Pugging, aging, etc., were the same as with the raw and H clays.

(2) Preparation of Bars

Bars were extruded from a deaired auger machine employing a vacuum of 28 inches of mercury. The extruded columns were $1^1/_8$ by $1^1/_8$ inches, and the cut bars were 6 inches long. The wet bars, weighing approximately 250 grams each, were wrapped in tin foil and stored in airtight jars until they were tested. Before testing, the ends of the bars were covered with grease to permit the moisture to escape only through the sides of the bar.

(3) Drying Procedure

A large drying oven with humidity control was used. The size of the drying chamber was 29 by 36 by 36 inches. The volume of test specimens was small compared to that of the drier because ordinarily only five bars were dried at a time. Forced draft kept the air in circulation, but the movement was not rapid

* Received October 18, 1939. Work done under Battelle Research Associate Fund.

[1] J. D. Sullivan and R. P. Graham, "Effect of Exchangeable Bases on Torsion Properties of Clays," *Jour. Amer. Ceram. Soc.*, this issue, p. 39.

[2] R. P. Graham and J. D. Sullivan, "Effect of Exchangeable Bases on Absorption and Transverse Strength of Clay Bodies," (this issue, p. 52).

[3] W. R. Morgan and R. K. Hursh, "Conditions Governing Diffusion of Water in Clays," *Jour. Amer. Ceram. Soc.*, **22** [8] 271–78 (1939).

[4] J. D. Sullivan, "Physico-Chemical Control of Properties of Clay," *Trans. Electrochem. Soc.*, **75**, 71–98 (1939).
See also footnote 1.

[5] R. P. Graham and J. D. Sullivan, "Critical Study of Methods of Determining Exchangeable Bases in Clays," *Jour. Amer. Ceram. Soc.*, **21** [5] 176–83 (1938).

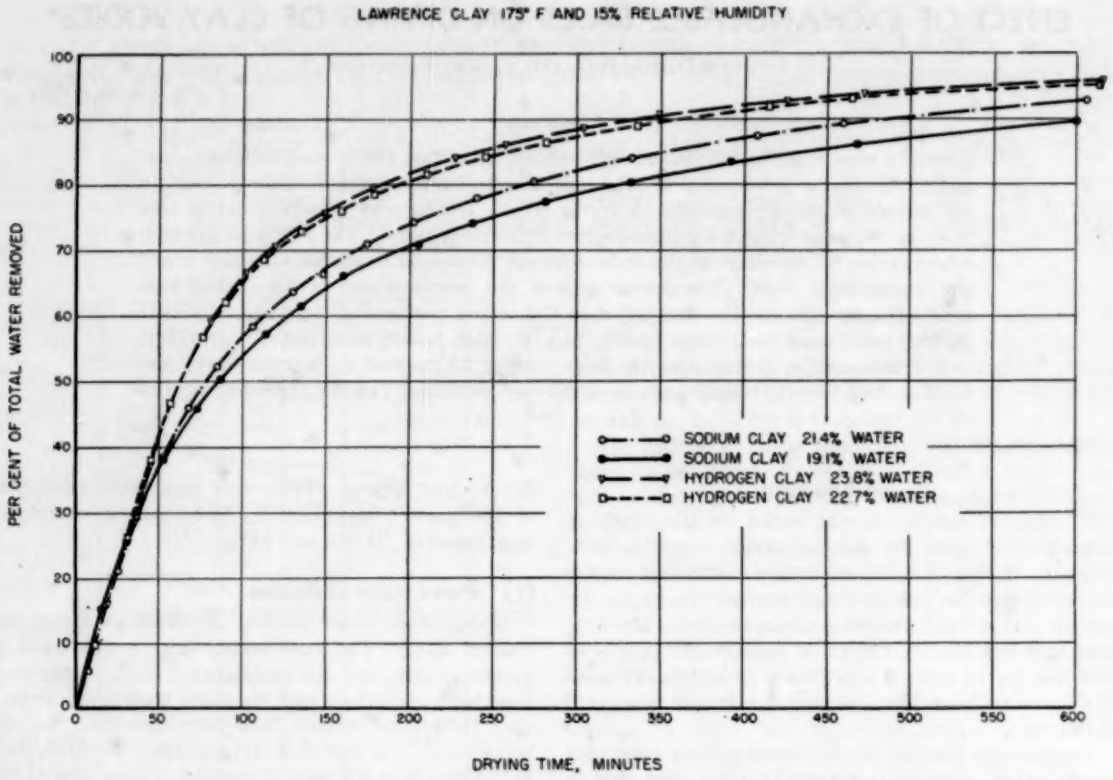

FIG. 1.—Drying Lawrence clay bodies of different water contents at 175°F. and 15% relative humidity.

enough to interfere with the specimens or with weighing. Balances were mounted above the drying cabinet, and the specimens, on saddles in the interior, were connected to the balances by means of fine wires passing through openings in the top of the cabinet. The balances were sensitive to 0.05 gram, and weighings were ordinarily taken to 0.1 gram.

(4) Results

Many tests were carried out, and the general conclusions given in this paper are based on the tests as a whole. Of the data collected, only enough are reported here to substantiate the conclusions.

As was to be expected, the rates of drying were much more rapid as the temperature increased. In fact, the temperature of 175°F. and 15% relative humidity was used to accentuate the drying effects caused by the different exchangeable bases.

All bars studied were in the workable stiff-mud range and varied in texture from moderately dry to medium. The water content in most cases was selected to give the bars of different bodies equal stiffness as exemplified by the maximum torque in the torsion tests. The general conclusion of tests at 150°F. and 50% relative humidity was that, in the workable stiff-mud range used with bars of a given type body (e.g., Na clay), the percentage of the total water removed from trials of different moisture content in a unit of time was more constant than the precision of measurement. At 175°F. and 15% humidity after about 50 to 60% of the water was removed, there was a perceptible difference in the rates with different water contents, the bodies with low water drying more slowly. The relative positions of the base-treated bodies, however, were not changed, i.e., whereas Na clay with 19.1% H_2O had a slower rate than one with 21.4% and likewise a H clay with 22.7% of H_2O had a slower rate than one with 23.8% both Na bodies dried less rapidly than either of the H bodies. Figure 1 gives data on Na and H clays with two water contents. In this and subsequent figures, water content is expressed as percentage, by weight, of the dry clay.

Figure 2 gives results on the four Lawrence clay bodies with water contents selected to give stiff-mud bodies with approximately the same stiffness. These curves are typical and show that all the bodies had approximately the same rates during the early stages of drying but that the rates were quite different in later stages.

Drying curves at 100°F. and 50% humidity and at 150°F. and 50% humidity were similar in shape to those at 175°F. and 15% humidity, although the rates were slower.

Figure 2 also shows that the most rapid drying rate was exhibited by H clay, with raw, Ca, and Na clays following in decreasing order. At 100°F. and 50% humidity and at 150°F. and 50% humidity after the break in the curve occurred, i.e., indicating sub-

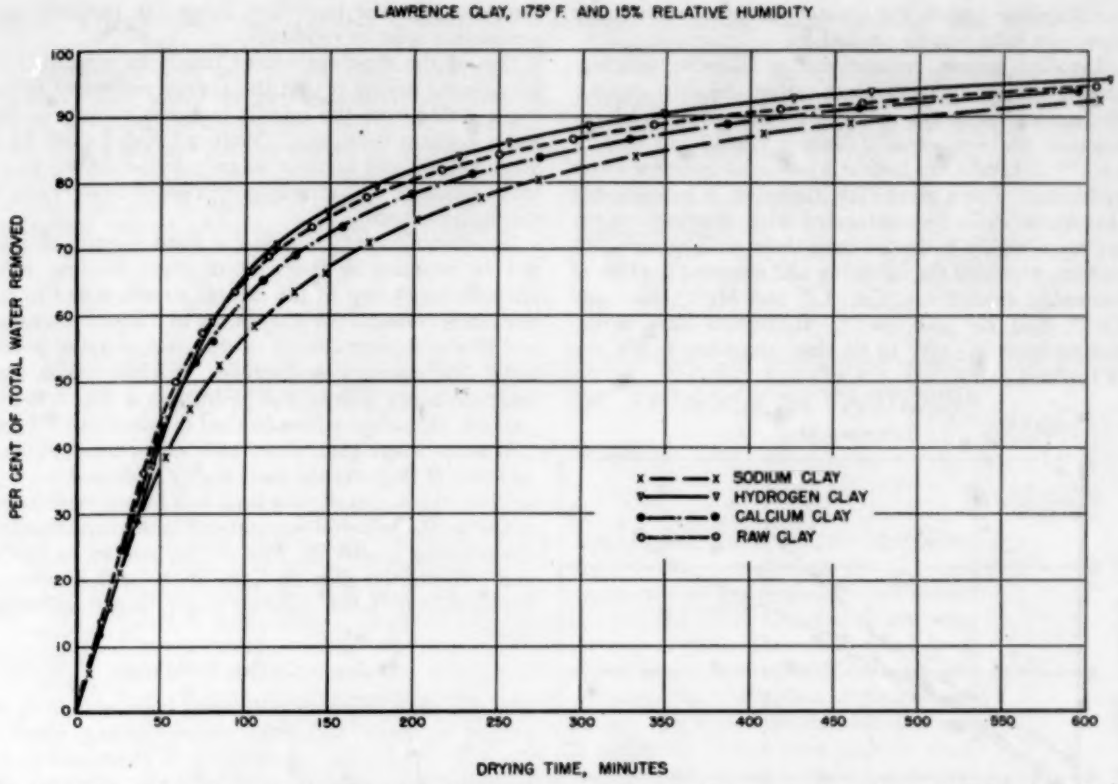

FIG. 2.—Effect of exchangeable bases on drying of Lawrence bodies of approximately equal stiffness at 175°F. and 15% relative humidity.

stantial completion of the drying shrinkage, the Na clay always had the slowest drying rate, and in a given period a less percentage of the total water was removed. There was less difference in the positions of the curves at the two lower temperatures because the drying rates were much slower.

(5) Drying Shrinkage

Figure 3 gives data on drying shrinkages of raw, Na, Ca, and H Lawrence clays with different water contents. The drying shrinkages increased with increasing water content. Linear shrinkage was calculated by the formula,

$$S = \frac{L_w - L_d}{L_d} \times 100.$$

Where S = linear shrinkage (%).
L_w = wet bar (length).
L_d = dry bar (length).

III. Discussion

Drying clay bodies involves the removal of both interstitial and adsorbed moisture. The initial period of drying in which shrinkage is pronounced probably represents, for the most part, the removal of interstitial moisture. Drying beyond this point may involve the removal of some interstitial moisture, but it also involves the removal of adsorbed water held by the clay particles. Adsorbed moisture is that moisture held by molecular and ionic attraction, including hydration of ions, and that held osmotically. As shown in previous papers by the authors,[6] the amount of water required to yield a body of given stiffness varies with the exchangeable base present on the clay particles, but this water of plasticity represents both interstitial and adsorbed water. A former paper[2] also showed that bodies requiring a low moisture content have lower unfired absorption than those requiring high moisture. The same is true of linear shrinkage as shown in Fig. 3.

The drying results obtained may be explained logically by a consideration of the nature of the colloidal condition that exists and of the physical nature of the body, particularly as illustrated by unfired absorption. A brief summary of the nature of the colloidal complex, therefore, is given.

The active or colloidal surface of clays and zeolites contains large cavities which are filled with adsorbed ions and water molecules. The number of water molecules which can be packed into a cavity depends on the number and size of the exchangeable ions within the cavity. For every monovalent cation adsorbed, a similar cation is released. In monovalent systems, the number of water molecules within the cavities depends on the size of the adsorbed ion. The smaller the

[6] See footnotes 1 and 4.

exchangeable cation, the greater the number of water molecules that can be packed in.

Divalent cation replacement is likewise stoichiometric, and for every divalent cation adsorbed another divalent cation or two monovalent cations are released. Because the volume of 2 Na^+ is 7.88Å^3 and that of 1 Ca^{++} is 4.99Å^3, the 2.89Å^3 is potential space for water molecules. For a given clay, therefore, it is concluded that those clays base-saturated with divalent cations are more highly hydrated than those with monovalent cations, provided the incoming and outgoing ions are of somewhat similar size, viz., Li^+ and Mg^{++}, Na^+ and Ca^{++}, and K^+ and Ba^{++}. Hydration likewise decreases from Mg clay to Ba clay, according to the size of the ions.

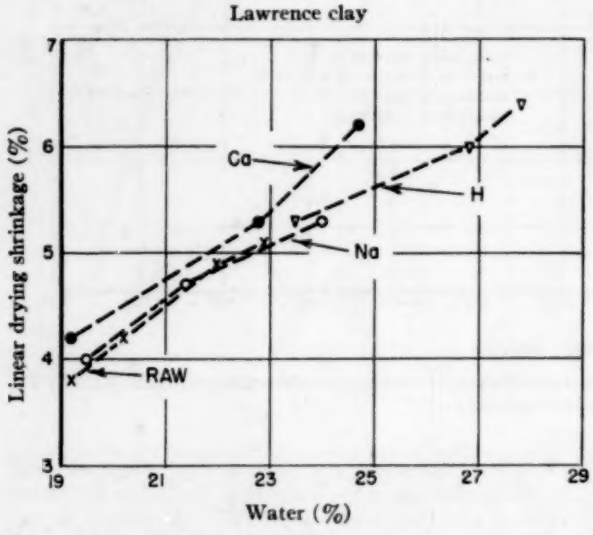

FIG. 3.—Total drying shrinkage, 105°C., of various base-treated Lawrence clay bodies.

Inasmuch as the H ion is the smallest of all and occupies very little space in the cavity, the latter can be filled to a greater extent with water. In the case of artificial permutites, the replacement of 1 Na^+ by 1 H^+ has been calculated to increase the amount of adsorbed H_2O by about 1 molecule. Experimental data, however, indicate that the number of water molecules in H systems is considerably greater than that provided by mere space relationships. Jenny[7] believes that the additional water molecules represent water of constitution.

Although there is no definite knowledge on the nature of molecularly attached water, the molecules probably occupy an oriented position instead of the random distribution in the intermicellar and interstitial solution. The water so adsorbed possesses properties different from free water; it is denser and has a different viscosity. In the innermost layers, it probably approaches a solid in rigidity.[8]

One of the most important points to remember in considering drying is that the energy necessary to remove water from the micelle increases rapidly as the water content decreases. Mattson[8] stated that, for a given colloid, the increase in pressure necessary to remove moisture is inversely proportional to the cube of the water content.

Relationships which hold for ideal conditions may not be realized in the case of clays because some changes may occur in the crystal structure and in the size of the colloidal particles owing to the ionic exchange and its consequent change in the electrokinetic potential. The conclusions, however, may be drawn that ionic exchange affects the hydration of the colloidal particle, that clays with adsorbed divalent cations contain more water than clays with monovalent cations, and that H clays are the most highly hydrated.

The foregoing discussion leads to a logical explanation of the drying behavior encountered in this investigation. Considering specifically the drying curves at 175°F. and 15% relative humidity, the degree of hydration, as exemplified by total adsorbed water, should follow the order

H clay > Ca clay > Na clay.

The raw clay, primarily a divalent body, should be expected to have properties approximating those of Ca clay. The water of plasticity, as illustrated by the moisture necessary to give uniform stiffness, also followed in the same order. The layer of adsorbed water was thickest in the case of H clay so that the effect of molecular attraction was least, and it should be most easily removed. The Na clay had the lowest water content, and the adsorbed water, which was held by the greatest molecular forces, was the most difficult to remove. The unfired absorption of H clay was highest and Na clay lowest. The Na clay, which had the smallest passageways from the interior to transport moisture to the surface for evaporation, therefore had greatest resistance.

The two factors, viz., (1) the difficulty of removal of adsorbed water, and (2) the pore space and size of passageways for the transportation of water from the interior of the body to the surface, co-operated to make Na clay the most difficult and H clay the easiest to dry.

The data in Fig. 1 agree with the theory outlined. In the case of both Na clay and H clay, the one with higher moisture content dried more rapidly. For a given base-saturated clay, this is to be expected because the higher the water content the greater the unfired absorption. Bodies with high absorption have more and larger passageways for water to be transported to the surface.

IV. Conclusions

At 100°F. and 50% relative humidity, 150°F. and 50% humidity, and 175°F. and 15% humidity, the

[7] Hans Jenny, "Studies on Mechanism of Ionic Exchange in Colloidal Aluminum Silicates," *Jour. Phys. Chem.*, **36** [Part II] 2217–58 (1932); *Ceram. Abs.*, **11** [12] 632 (1932).

[8] Sante Mattson, "Laws of Soil Colloidal Behavior: VIII, Forms and Functions of Water," *Soil Sci.*, **33** [4] 301–23 (1932); *Ceram. Abs.*, **11** [8] 469 (1932).

rate of drying of Lawrence clay is a function of the exchangeable bases on the clay particle. Although the differences were less at the lower temperature, Na clay dried slower in all cases after the phase of drying involving shrinkage was completed. The rate of drying decreased with less percentage removal of the total water in the case of Na clay than with other base bodies. At 175°F. and 15% relative humidity, the percentage rate of removal of water was faster with bodies of higher water content. The effect of exchangeable bases on drying rates is explained by (1) the differences in the amount of adsorbed water held by molecular and ionic attraction and by osmotic imbibition and (2) the differences in the water content required to yield bodies of given stiffness.

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CONTROL OF CRAZING IN SANITARY WARE GLAZES BY MAYER AND HAVAS COEFFICIENT OF EXPANSION FACTORS*

BY A. O. KNECHT

ABSTRACT

A brief history of glaze literature on coefficient of expansion and a short description of methods of determination are given. Using the factors of Mayer and Havas to calculate the coefficient of expansion of glazes from the percentage weights of their oxides, factors were calculated for glaze raw materials. Instead of the empirical formulas for raw materials, chemical analyses supplied by dealers of glaze materials were used. A series of glazes, starting with a high coefficient and gradually decreasing in coefficient, was tested. After determining from this series the calculated coefficient of the noncrazing glaze, a series was made in which the composition was varied and the coefficient was kept constant. Glazes of low coefficient did not craze. No crazing resulted when the composition of the glazes was varied and the calculated coefficient was kept constant. This method is a valuable means of controlling crazing in sanitary glazes because of its simplicity, the economy of experimental equipment, and the relatively short time required to complete the tests.

I. Introduction

The type of expansion measuring equipment used governs the type of glaze test pieces to be used. Three principal methods are being used by the investigators, viz., (1) a method of measuring directly the linear expansion of a test specimen in the form of a drawn glass rod[1]; (2) a method for low-temperature measurement only, which involves calculating the cubic expansion of a specimen from the amount of mercury overflowed from a filled glass vessel; and (3) the interferometer method.

II. Plant Control

Most of the equipment for thermal-expansion measurement is too expensive for use in the average whiteware plant. In addition to equipment for expansion and high-temperature measurement, the services of a chemical laboratory for the analysis of glazes would be necessary. A more practical control method is to calculate the comparative expansions by expansion factors.

Winkelmann and Schott,[2] early investigators in expansion of glass, determined a set of factors to calculate the expansion of a glass from the percentage by weight of their oxides. Mayer and Havas [3] later checked these factors and added many more for oxides used in enamel glasses. Their investigation is one of the most complete, and the factors are the best available for enamel glasses. Hall[4] calculated factors for glass-forming oxides from experimental work on 118 glazes and glasses.

III. Experimental Procedure

Using the factors of Mayer and Havas, the percentage by weight of the oxide multiplied by its factor gives the cubic coefficient of expansion. To use these factors, the composition of a glaze must be reported in terms of oxides. Instead of reducing the glaze composition to oxides, factors were calculated for fired glaze materials, using the Mayer and Havas factors as a basis. Most dealers in glaze raw materials will supply a chemical analysis of their materials. Using these analyses in-

* Presented at the Forty-First Annual Meeting, American Ceramic Society, Chicago, Ill., April 20, 1939 (Symposium on Glaze Properties). Received April 20, 1939; revised copy received August 31, 1939.

[1] G. E. Merritt and C. G. Peters, "Interferometer Measurements of Thermal Dilatation of Glazed Ware," *Jour. Amer. Ceram. Soc.*, **9** [6] 327–42 (1926).

[2] *Wiedemann's Annalen*, **51**, 731 (1894).

[3] A. I. Andrews, Enamels, p. 38. Twin City Printing Co., Champaign, Ill., 1935; *Ceram. Abs.*, **14** [6] 158 (1935).

[4] F. P. Hall, "Influence of Chemical Composition on Physical Properties of Glazes," *Jour. Amer. Ceram. Soc.*, **13** [3] 182–99 (1930).

stead of the empirical formulas of feldspar and clay, factors for fired clay and feldspar were calculated. This procedure eliminated some of the errors which would have resulted if the empirical formulas of feldspar and clay had been used.

TABLE I

CALCULATION OF FACTOR FOR FINDING CUBIC COEFFICIENT OF KEYSTONE FELDSPAR

Composition	(%)	Mayer and Havas factor*	Cubic coefficient
SiO_2	64.36	0.8×10^{-7}	51.49×10^{-7}
Al_2O_3	20.21	5.0×10^{-7}	101.05×10^{-7}
Fe_2O_3	0.024	4.0×10^{-7}	0.10×10^{-7}
CaO	0.37	5.0×10^{-7}	1.85×10^{-7}
MgO	0.03	0.1×10^{-7}	
K_2O	12.51	8.5×10^{-7}	106.34×10^{-7}
Na_2O	2.17	10.0×10^{-7}	21.70×10^{-7}
Ignition	0.33		
		Cubic coefficient	282.5×10^{-7}
		Feldspar factor	2.83×10^{-7}

* See footnote 3.

TABLE II

EDGAR PLASTIC FLORIDA KAOLIN (FIRED BASIS)

Composition	(%)	Mayer and Havas factor	Cubic coefficient
SiO_2	55.20	0.8×10^{-7}	44.16×10^{-7}
Al_2O_3	43.20	5.0×10^{-7}	216.00×10^{-7}
Fe_2O_3	0.94	4.0×10^{-7}	3.76×10^{-7}
CaO	0.17	5.0×10^{-7}	0.85×10^{-7}
MgO	0.23	0.1×10^{-7}	0.23×10^{-7}
Alkali	0.27	9.2×10^{-7}	2.57×10^{-7}
TiO_2	0.21	4.1×10^{-7}	0.86×10^{-7}
		Cubic coefficient	268.43×10^{-7}
		Clay factor	2.68×10^{-7}

A series of glazes was formulated to give a high expanding glaze as one end member and a much lower expanding glaze as the other end member. A high clay, feldspar, and whiting content with a low flint and zinc oxide content gave a glaze of high coefficient of expansion. A glaze of lower coefficient of expansion was obtained by reducing the feldspar, whiting, and clay content and by increasing the flint and zinc oxide. As the series moved from glazes of calculated high coefficient of expansion to those of lower coefficient, the crazing steadily decreased and was finally eliminated. Using the value of the calculated coefficient of expansion of the glazes in this series which did not craze, a trial series of fifteen glazes was tested in which the composition was varied but the calculated coefficient of expansion was kept as nearly constant as possible. None of the glazes of this series crazed. In no case was the coefficient of expansion reduced to the point where shivering was encountered.

IV. Test Methods

All of the glazes used in this study were one-fire, unfritted glazes which were fired on a vitreous china body. They were milled for four hours in laboratory jar mills. The series was blended at a constant specific gravity. The glazes were sprayed on unfired test pieces 6 inches in diameter. After they were fired once in a tunnel kiln at cone 12, they were again sprayed with glaze and fired a second time. It was found that two glaze firings gave a more severe test. The test pieces were then placed in an autoclave and were subjected to a steam pressure of 120 pounds per square inch for three hours. If no craze marks were visible after an ink test, the glazes were considered to be craze resistant.

TABLE III

MEMBER NO. 1 (SERIES A)

Composition	Weight (%)	Member No. 1 (Series A) Wt. (fired)	Weight % (fired)	Mayer and Havas factor	Cubic coefficient
Flint	20.0	20.0	22.4	0.8×10^{-7}	17.9×10^{-7}
Feldspar	34.5	34.5	38.7	2.8×10^{-7}	108.5×10^{-7}
Fla. kaolin	14.0	11.9	13.4	2.7×10^{-7}	36.2×10^{-7}
Whiting	20.0	11.2	12.6	5.0×10^{-7}	63.0×10^{-7}
Zinc oxide	6.2	6.2	6.9	1.8×10^{-7}	12.4×10^{-7}
Tin oxide	5.3	5.3	6.0	2.0×10^{-7}	12.0×10^{-7}
				Cubic coefficient	250.0×10^{-7}
				Linear coefficient	8.33×10^{-6}

TABLE IV

Member No.	Series	Composition (weight %) Flint	Feldspar	Fla. kaolin	Whiting	Zinc oxide	Tin oxide	Coefficient Cubic	Linear
10	A	33.0	24.0	10.4	18.0	9.0	5.4	215.6×10^{-7}	7.17×10^{-6}
1	B	20.0	34.5	14.0	20.0	6.2	5.3	250.0×10^{-7}	8.33×10^{-6}
10	B	34.5	23.0	11.0	20.0	6.2	5.4	217.9×10^{-7}	7.1×10^{-6}
1	C	34.5	23.0	11.0	20.0	6.2	5.3	217.9×10^{-7}	7.1×10^{-6}
11	C	34.5	23.0	16.0	15.0	6.2	5.3	214.0×10^{-7}	7.0×10^{-6}
15	C	34.5	32.0	11.0	11.0	6.2	5.3	208.6×10^{-7}	6.9×10^{-6}

(1) Effect of Calculated Expansion Change

A series of ten glazes was first made with a calculated high coefficient of expansion for one end member and gradually decreasing in coefficient to the other end member.

The trials of member No. 1 were badly crazed; crazing decreased as the composition moved toward member No. 10. Members Nos. 8, 9, and 10 did not craze.

Series C, with ten members and with slightly different composition from series A, was run (see Table IV).

The trials of member No. 1 were badly crazed; crazing decreased as the composition moved toward member No. 10; Nos. 9 and 10 did not craze.

A 15-member triaxial series of glazes (series C), varying in composition but of practically the same calculated coefficient of expansion, was made. The coefficient of expansion was that of member No. 10 of the B series.

None of the glazes in this entire series crazed. All were of the same or of less coefficient of expansion than glaze No. 10 of series B.

V. Summary

There are many sources of error to be found in calculating the coefficient of expansion of a glaze from its oxide composition. Various investigators[5] have proved that the coefficient of expansion is not a true linear function of the percentage weights of its constituent oxides although it closely approximates it. Webb[6] reports that varying the cooling rate of a glaze through its annealing range will change the coefficient of expansion. The solution of materials at the glaze-body interface contributes another error. Considering all of these factors, it is evident that the value of the coefficient of expansion, calculated from the percentage composition of its oxides, is not necessarily a true value but rather a comparative one. This fact, however, does not detract from its usefulness. The calculated coefficient of expansion is valuable because a series of glazes may be systematically varied from a high coefficient of expansion to an increasingly lower one until the proper glaze-body fit is effected.

This method of crazing control has been used successfully several times on regular production glazes. It is especially useful where crazing results from small changes in composition of raw materials or from changes due to the addition of coloring oxides. Knowing which materials will effect an increase or decrease in coefficient of expansion, the adjustment in glaze composition can be made at once.

Universal Sanitary Manufacturing Company
Camden Pottery Division
Camden, New Jersey

[5] S. English and W. E. S. Turner, "Relationship Between Chemical Composition and Thermal Expansion of Glasses," *Jour. Amer. Ceram. Soc.*, **10** [8] 551–60 (1927); p. 554.

[6] H. W. Webb, "Observations on Crazing," *Trans. Brit. Ceram. Soc.*, **38** [1] 75–87 (1939); p. 78; *Ceram. Abs.*, **18** [5] 132 (1939).

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February, 1940
19—2

Abrasives

Application of diamond-hard metal combinations for grinding purposes. W. Dawihl and A. Fehse. *Maschinenbau Betrieb*, **18**, 349–50 (1939); *Metals & Alloys*, **10** [11] MA 651 (1939).—The binder for diamond bort should be hard, in contrast to that used for silicon carbide grains, because the rate of interchange of grains in the case of diamond is much smaller. Hard metal (tungsten carbide) has expansion properties similar to those of diamond and wets the bort. When the tool is used for the removal of large quantities of material, coarse grain (0.15 to 1.0 mm.) is recommended. Finer grain (down to 0.06 mm.) should be used for finishing operations, and grains smaller than 0.06 mm. should be used for high polishing. Diamond grinding tools are cleaned with steel brushes. If they lose grip they are ground over with silicon carbide wheels of medium grade and sandblasted or etched to expose the bort. Applications for finishing sintered hard-metal tools for working glass, etc., are listed, and typical applications are described.

PATENTS

Abrasive article manufacture. S. S. Kistler (Norton Co.). Can. 384,156, Sept. 19, 1939 (July 14, 1937); see *Ceram. Abs.*, **18** [5] 118 (1939). G.M.H.

Abrasive material. J. N. Kuzmick and L. S. Hilton (Raybestos-Manhattan, Inc.). Can. 384,725, Oct. 17, 1939 (Feb. 2, 1938). G.M.H.

Abrasive object agglomerated with or by resin. Compagnie des Meules Norton (Soc. Anon.). Fr. 849,608 and 849,609, Jan. 28, 1939. D.A.B.

Abrasive tool guiding apparatus. Harry Morrison. U. S. 2,181,604, Nov. 28, 1939 (Dec. 17, 1936).

Abrasive-wheel manufacture. Baalis Sanford (Norton Co.). Can. 384,157, Sept. 19, 1939 (Jan. 8, 1938); see "Making—," *Ceram. Abs.*, **18** [2] 42 (1939). G.M.H.

Abrasive-wheel mount. Thure Larsson (Norton Co.). Can. 384,445, Oct. 3, 1939 (June 10, 1937). G.M.H.

Air conditioned buffing and polishing system. Guerin Todd and Octavius Knight (Hanson-Van Winkle-Munning Co.). U. S. 2,182,952, Dec. 12, 1939 (April 30, 1938).

Apparatus for honing. H. L. Blood (Heald Machine Co.). U. S. 2,182,276, Dec. 5, 1939 (Nov. 5, 1936).

Apparatus for recovering the grinding wheels used on machines for rectifying wheels, etc. Soc. Française d'Engrenages à Denture Rectifiée. Fr. 849,490 and 849,491, Aug. 3, 1938. D.A.B.

Apparatus for truing, grinding, and abrasive wheels. Kapella, Ltd., and E. A. Cooke. Brit. 514,048, Nov. 8, 1939 (April 11, 1938).

Attachment for cutter grinders. R. K. Le Blond (R. K. Le Blond Machine Tool Co.). U. S. 2,182,231, Dec. 5, 1939 (June 14, 1939).

Centrifugal device for grainlike charges on abrasive, polishing, and ignition machines. Karl Grocholl. Ger. 678,588, June 22, 1939 (Nov. 23, 1933); XII/67*b*. Addition to Ger. 591,671.—The outer ends of one or more blades employed in the device are formed in such a manner that a greater angle of tangency results on the sides facing the direction of rotation than on the side or part of the blade curving backward. D.A.B.

Device for grinding knife blades. Jakob Nix. Ger. 677,174, May 25, 1939 (May 6, 1936); XII/67*c*. 4.—In a device for grinding knife blades, the knife blade moves back and forth on a support between two turnable abrasive bodies. The support holds the blade in position by means of a ridge and can be adjusted for blades of various sizes. The abrasive surfaces are parallel to each other. D.A.B.

Grinding cam shafts. Friedrich Deckel Präzisions-Mechanik u. Maschinenbau. Ger. 678,981, July 6, 1939 (Oct. 27, 1936); XII/67*a*. 31.03.—A method is given for the grinding of cam shafts, especially those with hollow places of proportionately small radius. The circumference of the cam is first worked by a grinding disk which operates perpendicularly to the axis of the cam shaft and whose cross section is of a radius equal to or smaller than the smallest radius of curvature on the circumference of the cam. The working of the remaining section of the circumference is performed by a grinding disk of larger diameter which is attached to an axis arranged similarly to that of the first grinding disk. D.A.B.

Grinding cylindrical articles between two abrasive disks. Schumag Schumacher Metallwerke A.-G. Fr. 847,943, Dec. 23, 1938. D.A.B.

Grinding machine. KARL JUNG. Ger. 678,845, June 29, 1939 (March 5, 1927); XII/67*a*. 33.—A hydraulic cooling attachment is described. D.A.B.

Grinding machine. T. C. KASEBERG (American Car and Foundry Co.). U. S. 2,180,529, Nov. 21, 1939 (June 5, 1937). I. A. TAYLOR (Norton Co.). U. S. 2,183,494, Dec. 12, 1939 (Nov. 18, 1938).

Grinding vitreous materials. COMPAGNIE FRANÇAISE POUR L'EXPLOITATION DES PROCÉDÉS THOMSON-HOUSTON. Fr. 849,715, Feb. 1, 1939. D.A.B.

Grinding wheel. CARL L. LEAFE (Norton Co.). Can. 384,446, Oct. 3, 1939 (June 18, 1937). G.M.H.

Grinding-wheel manufacture. A. T. SOHLSTROM (Norton Co.). Can. 384,158, Sept. 19, 1939 (Jan. 8, 1938; in U. S. Jan. 12, 1937). G.M.H.

Grinding wheel for soft materials. ANTON MONTAGNÉ. U. S. 2,183,082, Dec. 12, 1939 (Oct. 15, 1935).

Grinding wheels or agglomerated abrasive objects. COMPAGNIE DES MEULES NORTON (SOC. ANON.). Fr. 849,607, Jan. 28, 1939. D.A.B.

Honing structure. E. F. BROWER (Micromatic Hone Corp.). U. S. 2,181,011, Nov. 21, 1939 (March 15, 1937).

Honing tool. E. F. BROWER AND W. H. HARRIS, JR. (Micromatic Hone Corp.). U. S. 2,181,010, Nov. 21, 1939 (Feb. 13, 1937).

Hydraulic grinding-wheel feed. A. G. BELDEN AND R. A. COLE (Norton Co.). Can. 384,155, Sept. 19, 1939 (June 28, 1937); see *Ceram. Abs.*, **17** [7] 241 (1938). G.M.H.

Hydraulically operated cylindrical grinding machine. C. G. FLYGARE (Norton Co.). U. S. 2,183,490, Dec. 12, 1939 (July 15, 1939).

Machine for grinding the crankpins of crankshafts. C. MAYER AND R. NOLLE. Brit. 514,022, Nov. 8, 1939 (Aug. 29, 1938).

Mandrel and polisher for polishing and grinding devices. H. R. BERGER (J. F. Jelenko & Co., Inc.). U. S. 2,181,474, Nov. 28, 1939 (Feb. 16, 1938).

Manufacture of abrasive-coated articles. W. J. TENNANT (Carborundum Co.). Brit. 513,884, Nov. 8, 1939 (April 22, 1938).

Manufacturing abrasive objects. COMPAGNIE DES MEULES NORTON (SOC. ANON.). Fr. 849,606, Jan. 28, 1939. D.A.B.

Manufacturing abrasive paper. C. KLINGSPOR. Fr. 849,738, Feb. 1, 1939. D.A.B.

Manufacturing grinding wheels. FIRMA ALBERT STRASMANN PRÄZISIONS WERKZEUG UND MASCHINENFABRIK. Fr. 849,995, Feb. 7, 1939. D.A.B.

Mechanism for truing grinding wheels. JONES & LAMSON MACHINE CO. Brit. 514,586, Nov. 22, 1939 (Aug. 26, 1937).

Mounting for a grinding wheel. J. M. REDINGER. U. S. 2,180,550, Nov. 21, 1939 (Feb. 5, 1938).

Producing an abrasive. I. G. FARBENIND. A.-G. Ger. 678,842, June 29, 1939 (Aug. 12, 1933); IV*c*/39*b*. 22.—An abrasive is formed by using the condensation products of maleic acid or maleic acid anhydride and castor oil as the binding agent. D.A.B.

Producing abrasive articles bonded with rubber. CARBORUNDUM CO. Ger. 677,689, June 1, 1939 (Jan. 3, 1935); IV*c*/39*b*. 5.—Abrasive articles with rubber as binding agent are produced from a mixture of abrasive particles and an artificial aqueous rubber dispersion which is coagulated and dried just enough so that the moisture contents of the mixture and of the surrounding air are alike in weight. The dried and pulverized mixture is compressed by passing it between revolving rollers which are spaced far enough apart to avoid crushing of the abrasive particles. The articles produced by forming, stamping out, or cutting out of the resulting rolled sheets are vulcanized. D.A.B.

Producing boron carbides with low carbon content. ALEXANDER WACKER GES. FÜR ELEKTROCHEMISCHE INDUSTRIE, G.M.B.H. Ger. 677,189, May 25, 1939 (Sept. 17, 1935); IV*b*/12*i*. 37.—A method is given for producing boron carbides with low carbon content from boric acid and carbon. A mixture of boric acid and carbon in an amount that will result in a product of higher content in carbon is first melted down in a known manner in an electric arc or resistance furnace; the pulverized melt product is then mixed with additional boric acid in the correct amount and subjected to a second heating and working process. D.A.B.

Skate sharpener. Z. M. SMOLAREK. U. S. 2,181,923, Dec. 5, 1939 (Aug. 5, 1938).

Surface-grinding apparatus. R. A. COLE (Norton Co.). Can. 384,447, Oct. 3, 1939 (July 29, 1937; in U. S. Aug. 1, 1936). G.M.H.

Synthetic resin for the manufacture of grinding wheels, etc. COMPAGNIE DES MEULES NORTON (SOC. ANON.). Fr. 849,603 to 849,605, Jan. 28, 1939. D.A.B.

Treating silicon carbide grains. A. A. KLEIN (Norton Co.). U. S. 2,183,044, Dec. 12, 1939 (Feb. 19, 1938).—The method of treating silicon carbide grains and improving the strength thereof comprises the steps of heating the grains in a substantially pure condition, holding them at a temperature between 1000° and 1400°C for a considerable time, while limiting the oxidation so as to produce substantially smooth, nonpitted, lustrous surfaces, and thereafter cooling them slowly to anneal the grains and prevent detrimental strains being set up therein.

Art and Archeology

Ancient ritual clay vase. ANON. *Illus. London News*, **103** [2687] 735 (1938).—A 7-in. clay vase, dated 2300 B.C., was discovered at Brak, near the palace of Naram-Sin. It is decorated with appliqué snakes and scorpions and engravings of a tree, the sun, and circles. Illustrated. See "Prehistoric—," *Ceram. Abs.*, **18** [7] 172 (1939). L.F.M.

Artware with all the qualities of vitrified sanitary ware. ANON. *Ceram. Ind.*, **29** [5] 346–51 (1937).—A discussion is presented of the processes and materials used by the Sanitary Mfg. Co., Abingdon, Ill., in diversifying its production from large, heavy, bulky sanitary ware to beautiful, delicate artware and pottery which is winning great popularity. Illustrated. E.J.V.

Atchana pottery. LEONARD WOOLLEY. *Illus. London News*, **103** [2682] 504–505 (1938).—Unknown painted ware, associated with the Horites of the Old Testament, and Syrian, Mycenean, and Cypriote Bronze Age types are illustrated. Some of these vessels are decorated with animal and bird designs. See "Prehistoric—," *Ceram. Abs.*, **18** [7] 172 (1939). L.F.M.

Ceramic design and the market. JOHN A. FOSTER. *Bull. Amer. Ceram. Soc.*, **18** [12] 457–58 (1939).

German and Dutch glass. FRANK DAVIS. *Illus. London News*, **103** [2686] 702 (1938).—Green and ruby glass bowls, wine bottles, and goblets of the 17th century are decorated with Dutch inscriptions. Illustrated. L.F.M.

Gustav Hottinger. ANON. *Bull. Amer. Ceram. Soc.*, **18** [12] 476 (1939).

Hungarian peasant pottery. SHEILA IRVING REIN. *Connoisseur*, **104** [456] 73–78 (1939).—This pottery is hard to classify because of its variety and wide local. From the lowlands under Turkish dominance comes simple ware in rich warm colors, while in the North, thriving Germanic towns with potters' guilds dating from the 16th century produce cool blues, greens, and yellows on a white ground with peasant baroque and rococo. The little known pre-sixteenth century work is represented by some flat dishes found in early Avar tombs (568 to 880 A.D.) and some Gothic stove tile unglazed and molded from wood blocks. Painted colors date from the early 17th century,

and the decorations were lumpy clay ornaments in relief, after wood carvings. The common pottery of the peasants was plain green and undecorated; the decorated colored pieces were for the kitchens of the gentry and for ceremonial occasions. The primitive painting technique handed down through the years was done with a fine nozzled instrument, the *gurguly*, made from the pierced tip of a cow's horn, through which the color was squeezed from a funnel-shaped bag. The *gurguly* pottery, which was made southwest of the Danube, had lemon, green, or black ornaments on a striking ginger or black ground. At Szentes a smoked ware was made by filling the furnace after firing with damp wood or straw, lighting it, and sealing the oven. Patterns were then polished on with pebbles. The Habans were responsible for the formal beauty characteristic of upper Hungary. Illustrated. See "Old Hungarian—," *Ceram. Abs.*, **18** [1] 5 (1939). M.E.P.

Kutani and Hirado porcelain; Todd collection. R. S. JENYNS. *Brit. Museum Quarterly*, **13** [3] 70 (1939).—The Japanese collection in the British Museum has been enriched by a very fine Kutani porcelain plate (17th century) decorated with fruits growing on a tree and flying insects and a sauce boat and two decorated dishes of Hirado porcelain (early 19th century), the finest blue and white ware ever made by the Japanese. The Kutani dish is illustrated. A.B.S.

Mat glazes and the lime–alumina–silica system. HEWITT WILSON. *Bull. Amer. Ceram. Soc.*, **18** [12] 447–54 (1939).

Metallic luster in glost firing. L. V. L. NARASINGHA RAO. *Ceram. Age*, **32** [6] 172 (1938). F.G.H.

William de Morgan (1839–1917). ANON. *Times Lit. Supp.*, No. 1972, p. 673 (1939).—A critical study is given of the literary work of the famous ceramist. K.W.W.B.

National Youth Administration in ceramic art. VERA ODEYNE NEFF. *Bull. Amer. Ceram. Soc.*, **18** [12] 463–65 (1939).

North American Indian art. GEORGE C. VAILLANT. *Magazine of Art*, **32** [11] 622–27 (1939).—North American Indian culture was not unified because the various tribes had such different modes of living, hunting, fishing, and agriculture. Their achievements are on a neolithic plane, as they did not have metal tools or transportation other than dogs until they were introduced by the Europeans. The predominant esthetic expression of the Indian is in pure design, and the geometric basketry designs, when applied to other media such as pottery, skin containers, etc., retain their abstract character in most cases. An exception is found in the Mimbres pottery of the Southwest where naturalistic elements and curvilinear designs are used on effigy bowls and jars. The potter's art held a fascination for the Indian and he developed it to the full. The pottery designs are warm and alive with a personal quality not found in modern European ceramics, and function is paramount. The emotional principles back of North American Indian art are based on the idea of group work for common good, yet the individual initiative may be seen in the infinite variety of design and form. Illustrated. M.E.P.

Pottery in India. S. C. GUHA. *Ceram. Age*, **32** [3] 77–78 (1938). F.G.H.

Problems of designing for industry. EDWARD W. ENTHOF. *Bull. Amer. Ceram. Soc.*, **18** [12] 459–60 (1939).

Verzelini goblet of 1577. H. GRANVILLE FELL. *Connoisseur*, **104** [455] 42 (1939).—A recently unearthed glass by Giacomo Verzelini is of smoky, blackish colored metal with minute bubbles and is minus its original stem and foot. There is no record of a Verzelini earlier than this. The date is about 2 years after that of Verzelini's patent to make glasses in the Venetian manner, which was granted by Queen Elizabeth. Only 8 identifiable specimens of his diamond engraved glasses are known. M.E.P.

Windows of the great central space of Liverpool Cathedral. JAMES H. HOGAN. *Jour. Soc. Glass Tech.*, **23** [98] 239–41T (1939).—Three large lancet windows crowned by a rose form one composite with a total glass area of 1800 sq. ft. The making of them was one of the most important commissions in the art of stained glass in this century. The general character of the design and its relationship to that of the cathedral as a whole are discussed. The glass varies in thickness from $^3/_8$ to $^1/_2$ in. All colors are strongly textured by means of bubbles or the use of frit in order to diffuse the light, so that even on a dull day the windows have a luminous effect. G.R.S.

Work of Professional and Service Division, Works Progress Administration, in ceramics. WHITNEY ATCHLEY. *Bull. Amer. Ceram. Soc.*, **18** [12] 460–62 (1939).

BOOKS

Color in Theory and Practice: Vol. I, General Theory. H. D. MURRAY AND D. A. SPENCER. Chapman and Hall. Price 25s. Reviewed in *Times Lit. Supp.*, No. 1958, p. 482 (1939).—The complete work is particularly concerned with the photographic aspect. The first volume deals with the broad theory of the subject, treating the chemistry, physics, and psychology of color. Illustrated. K.W.W.B.

Corpus Vasorum Antiquorum. Fascicule 3. United States of America. Robinson Collection. DAVID MOORE ROBINSON AND SARAH ELIZABETH FREEMAN. Harvard University Press. Reviewed in *Times Lit. Supp.*, No. 1940, p. 206 (1939).—This completes the description of Greek and Italian vases in various American museums. Illustrated. See *Ceram. Abs.*, **9** [8] 610 (1930). K.W.W.B.

Mosaics of Antioch. C. R. MOREY. Longmans, Green & Co., New York. Price 31s 6d. Reviewed in *Times Lit. Supp.*, No. 1952, p. 394 (1939).—M. gives an account of recent excavations and a study of the development of the art of mosaic in Antioch. Illustrated. K.W.W.B.

PATENTS

Designs for:

Bathtub. F. C. GRIMM. U. S. 118,014, Dec. 12, 1939 (Aug. 26, 1939).

Bottle. GEORGE SMITH, JR. (Olean Glass Co.). U. S. 117,983, Dec. 5, 1939 (April 1, 1939).

Covered casserole. J. P. THORLEY (Hall China Co.). U. S. 117,857, Nov. 28, 1939 (March 7, 1939).

Fresnel lens. EMILIO PASCUCCI (Corning Glass Works). U. S. 117,934, Dec. 5, 1939 (Oct. 13, 1939).

Glass bottle. A. C. MEYER (Glenshaw Glass Co.). U. S. 117,980, Dec. 5, 1939 (Dec. 15, 1938).

Glass relish dish. DONALD DESKEY (Federal Glass Co.). U. S. 117,740, Nov. 21, 1939 (Oct. 19, 1939).

Jar. GEORGE SMITH, JR. (Olean Glass Co.). U. S. 117,844, Nov. 28, 1939 (June 3, 1938).

Lavatory. G. W. KOHLMEYER AND JAMES FRASER (W. A. Case & Son Mfg. Co. and Speakman Co.). U. S. 117,810, Nov. 28, 1939 (Aug. 8, 1939).

Plate. MARCELLINE GOUGLER (Mayer China Co.). U. S. 117,840, Nov. 28, 1939 (Aug. 2, 1939). C. W. LEIGH (Morimura Bros., Inc.). U. S. 117,790 to 117,794, Nov. 28, 1939 (Oct. 20, 1939). U. S. 117,811 to 117,820, Nov. 28, 1939 (Oct. 20, 1939).

Shirred-egg dish. J. P. THORLEY (Hall China Co.). U. S. 117,858, Nov. 28, 1939 (March 7, 1939).

Teapot. J. P. THORLEY (Hall China Co.). U. S. 117,855 and 117,856, Nov. 28, 1939 (March 7, 1939). U. S. 117,859, Nov. 28, 1939 (Sept. 14, 1939).

Producing decorations on ceramic surfaces. KERAMISCH-CHEMISCHE WERKE A.-G. VORM. DR. ALLERS UND HELLER TEPLITZ-SCHONAU. Fr. 836,580, April 13, 1938. D.A.B.

Producing deep-relief ornamentations on ceramic products. PORZELLANFABRIK LORENZ HUTSCHENREUTHER A.-G. Ger. 678,522, June 22, 1939 (Nov. 15, 1937); VI/80*b*. 23.06. Addition to Ger. 532,499.—The surfaces to be decorated by the etching process as given by this patent or by any other process are first chipped off; the metallic preparations and vitrifiable pigments are then applied, and the ornamentations are fused in. D.A.B.

Rendering impressions on nonabsorbing surfaces. ANIGRAPHIC PROCESS, INC. Fr. 836,330, April 7, 1938. D.A.B.

Transferring photographic designs on ceramic ware. W. D. FORD. U. S. 2,181,452, Nov. 28, 1939 (Oct. 16, 1936).—The method of transferring a relief or intaglio design contained on a substantially flat surface to a curved or irregular surface comprises distributing a moldable thermoplastic material in a heated fluid state on a substantially flat design-containing surface of a primary mold, allowing the moldable thermoplastic material to cool and solidify to form a flexible matrix bearing in one surface thereof the design of the primary mold, removing the matrix from the primary mold following cooling and solidification thereof and placing it on a shaping form which possesses the cross-sectional configuration of a final design-receiving surface, the design-containing surface of the matrix being arranged in direct contact with the shaping form, producing an intermediate mold from the shaping form with the matrix inlaid in one surface of the intermediate mold and with the design-containing surface of the matrix exposed to the outside of the intermediate mold, and molding a final pattern mold from the matrix-containing surface of the intermediate mold.

Cements

Radiographic study of the evolution of cements. EDITH COUILLAUD. *Compt. Rend.*, **209** [8] 397–99 (1939).—C. made a systematic study of the influence of temperature on the compression resistance of specimens of hydraulic binders. Four types were examined, viz., artificial Portland cement, lime cement, slag cement, and aluminous cement (*fondu* Lafarge). The conclusions from the radiographic investigation are as follows: (1) all the investigated clinkers are crystallized; and (2) in the setting process of the specimens, rays found in the fused part differ from those found in the clinker; a modification of the mineralogical composition must therefore have taken place and other crystals must have been formed. In the first three binders, the velocity of formation of new crystals varies with temperature, but after 3 to 7 days, depending on the binder, this effect stops and all radiograms become identical at different temperatures with only very slight modifications as functions of time. The increase of mechanical strength with time and temperature can be ascribed to an increase in the number or shape of the crystals, to a modification in their interlacing, or to their relative position. The fourth type (*fondu* Lafarge) shows the same radiographic behavior of compressive strength at 0.5° and 18°C. After 5 hours 'aging, the radiograms are identical with those of the clinker; after 8 hr. certain rays disappear, and more or less numerous and oriented groups appear, indicating the presence of sand grains in the cement. After 3 hr. in water at 70°C, the specimens aged 8 hr. are completely modified, some very distinct rays appear, and rays due to the presence of sand disappear. Irrespective of age, specimens treated at 45° and 70° give radiograms identical with those aged 8 hr. The mineralogical constitution changes, and, at the same time, the mechanical strength deteriorates under the action of heat; this is probably due to the formation of the cubic Al hydrate, $Al_2O_3 \cdot 3CaO \cdot 6H_2O$. In the powdered specimen of this heat-treated cement, all rays of the aluminate and two rays from another constituent were found. This seems to confirm a theory previously given by Lafuma on the behavior of this cement. M.H.

Serviceability of pottery plasters: I, Relation of physical properties to serviceability. J. F. MCMAHON AND H. G. SCHURECHT. *Bull. Amer. Ceram. Soc.*, **18** [12] 454–57 (1939).

BOOK

American Standard Specifications for Gypsum Plastering, Including Requirements for Lathing and Furring. Amer. Standards Assn., New York; Amer. Soc. Testing Materials, Philadelphia, 1939. Price 25¢.—The results are given of the work done by the A.S.T.M. Committee on Specifications for Plastering; these results were approved by the American Standards Association. F.F.

PATENTS

Adhesive Portland cement. LLOYD L. SMITH. Can. 384,525, Oct. 10, 1939 (May 25, 1938). G.M.H.

Manufacture of cement from calcium sulfate and blast-furnace slag. J. S. DUNN, R. G. FRANKLIN, V. LEFEBURE, AND IMPERIAL CHEMICAL INDUSTRIES, LTD. Brit. 513,897, Nov. 8, 1939 (Feb. 22, 1938). J. S. DUNN, V. LEFEBURE, AND IMPERIAL CHEMICAL INDUSTRIES, LTD. Brit. 513,898, Nov. 8, 1939 (Feb. 22, 1938). N. E. WALLACE, V. LEFEBURE, AND IMPERIAL CHEMICAL INDUSTRIES, LTD. Brit. 513,899 to 513,901, Nov. 8, 1939 (Feb. 22, 1938).

Manufacture of cement containing fibrous components. V. LEFEBURE, J. S. DUNN, N. E. WALLACE, AND IMPERIAL CHEMICAL INDUSTRIES, LTD. Brit. 513,903, Nov. 8, 1939 (Feb. 22, 1938).

Producing cement in two stages. OLE ROLFSEN. Ger. 679,522, July 13, 1939 (Feb. 16, 1937); VI/80*b*. 3.12.—In the first step, a small amount of lime is worked with the material so that only a dicalcium silicate results. D.A.B.

Rapid cooling of cement clinker by circulation. E. R. C. RONNE. Fr. 848,746, Jan. 11, 1939. D.A.B.

Enamel

Black and colored ground enamels. ANON. *Glashütte*, **69** [39] 690–91 (1939).—One coat enamel or enamel fired only once has been made only in the last 10 to 15 years. The enamel forms its own ground. It must have good adhesion, color, and luster and high resistance to firing, and it must fuse uniformly. An enamel batch suitable for one firing is quartz 5, feldspar 40, fluorspar 4, soda 6, Na saltpeter 3, borax 40, cobalt oxide 1.5, and pyrolusite 0.5 parts, and the mill batch is granulated metal 100 parts, yellow clay 10, quartz powder 15, "black substance" 5 to 10, borax 1. Good results are also obtained when two different ground enamels, a difficultly fusible melt and an easily fusible melt, are mixed; the borax content is reduced because difficultly fusible ground enamels are made without borax. A sample batch is given. The most suitable values for fineness of grinding, thickness of the enamel coat, firing temperature, and time must be accurately determined in order to obtain a good smooth enamel. A smooth black enamel having a good appearance is the easiest to produce. Lead enamels can be used where there is to be no contact with food; they adhere well to sheet iron and are smoother and shinier than lead-free enamels. To obtain a dark blue ground enamel, the same batch can be used with a greater addition of cobalt oxide (about 1 to 2%), but the firing time and temperature must be carefully regulated. A new blue ground enamel is obtained by the addition of 1 to 2% "blue-green oxide" to the mill. A green ground enamel is produced by adding chrome oxide to the mill. M.V.C.

Cast iron, pottery, and sanitary wet enamels, past and present. H. KERSTAN. *Glashütte*, **69** [41] 714–15 (1939).—The composition and chemical analysis of wet ground enamels for pottery and sanitary ware are given in tables. In the earlier batches the low B_2O_3 content, high Al_2O_3 content, and relatively high expansion coefficient are notable; cryolite was first used in enamels in 1890. K. describes the method of making enamels in the past. M.V.C.

Dip and spray enamel ground coat for better finish. ANON. *Ceram. Ind.*, **33** [6] 39–40 (1939).—The Cribben & Sexton Co., stove manufacturers, has followed the present trend in the enameling industry toward finer

grinding; the enamels are milled until 1% residue is left on a 200-mesh screen. This practice allows thinner coatings of enamel with high reflectance, thereby reducing the chipping tendency and saving on the cost of raw materials. Frit is milled with 8% opacifier addition. Unit stove bodies are coated with ground coat by first dipping them in a fairly "thin" slip to give about half of the desired coating and then adding the remainder of the ground coat by an overall spraying. This method allows utilization of the advantages of both methods, i.e., the uniform distribution of dipping and the smooth surface finish of spraying. L.M.C.

Effect of enamel on the strength of enameling iron. A. I. ANDREWS AND E. W. DIETTERLE. *Jour. Amer. Ceram. Soc.*, **23** [1] 29–32 (1940).

Enameling defects and their origin. R. ALDINGER. *Glashütte*, **69** [34] 589–92 (1939).—Enamel often breaks off at convexly curved edges when the enamel is subjected to compression. The smaller the radius of curvature and the weaker the expansion coefficient of the enamel, the more easily the enamel breaks. Most frequently the ground enamel holds and only the coat enamel breaks off. If the ground enamel also bursts, adherence is insufficient (deficiency of adhering oxides) or the firing technique is incorrect. When the *t* of the kiln is too high and the edges are too exposed to heat rays, the iron does not have time to oxidize sufficiently before the fusion of the ground coat enamel, and adherence is poor. If the furnace is too cold and firing and fusion of the enamel are too prolonged, oxidation is too great and adherence is likewise endangered. It is therefore necessary to regulate the firing of objects with curved edges with great care. Other factors, such as excessive thickness of enamel coat in proportion to the thickness of the metal, also cause enamel to break from edges. This may occur when the contour of the curve is such that the enamel runs toward the edge. Dark points in enamel are found especially in white or light enamels. The impurities may come from dust which clings to the wet enamel. Cleanliness in workshop and apparatus is therefore necessary. Impurities may originate in the frit itself, from metallic zinc and tin in the oxides and metals used as raw materials, from disintegration of the furnace lining during the fusion of enamels, or from particles of coke where the furnace is heated with oil and the burners function badly. Large gas bubbles retained in the fired enamel can also cause spots and dark points. When these bubbles reach and break through the surface, craters are formed and show as dark points. When incompletely enclosed, the enamel appears covered with dark streaks. To avoid this the enamel should be made more refractory by the addition of up to 10% of ground glass. M.V.C.

Fine cracks in enamel. ALDINGER. *Glashütte*, **69** [43] 738–39 (1939).—Fine cracks occur in enamel during cooling, when the fired enamel coat contracts more strongly than the iron. The fine cracks are not noticed until the article is put into use and dirt or rust from the iron underneath makes them visible. The presence of hairlines can be ascertained by sponging the article with a dye solution. Crazing is more common in enamel on cast iron than in that on sheet iron because of the greater variation in the composition of cast iron. The expansion of the enamel must be constantly checked and must be lower than that of the cast iron. If hair cracks appear over the entire surface of the article, the heat expansion of the enamel is too high; this may be due to a change in the raw materials or in the grinding or fusing processes. A sample batch of an enamel which crazes and a corrected batch composition in which the expansion is lowered and crazing prevented are given. Hair cracks are frequently found on the edges of utensils and are caused by a sudden localized cooling of the enamel. The bottoms of utensils often show crazing when the hot ware emerging from the furnace is placed to cool on a cold metal support instead of on asbestos. Uneven cooling or differences in the thickness of the metal may also cause crazing; this may be remedied by cooling the ware as slowly as possible. M.V.C.

Finishing of enameled and decorated signs. C. A. LITZLER. *Ind. Heating*, **6** [11] 1068–77 (1939).—L. describes the installation of a "lithograph" type of furnace for firing the finish on signs which are either roll-coated, lithographed, or silk-screen processed; the oven is 74½ ft. long, 15¼ ft. wide, and 8¾ ft. high. During the whole progression through the oven, the signs are in a horizontal plane. The cooling zone has two compartments; in the first the temperature is reduced to 150°F, and in the second it is reduced to slightly more than room temperature where the signs are kept for a certain amount of time before being discharged. M.H.

Manufacture of acid-stable enamels. VIELHABER. *Emailwaren-Ind.*, **16** [35–36] 221–22 (1939).—Acidproof enamel batches (Andrews) which were defective when fired on metal are given. V. concludes that tests for acid stability are important only for enamels whose value for enameling work has already been established. M.V.C.

Mat enamels. VIELHABER. *Emailwaren-Ind.*, **16** [37–38] 228–29 (1939).—For articles for which a mat enamel is desired, such as for blackboards, the mat effect can be obtained on glossy enamels by sandblasting, salt treating, etching with hydrofluoric acid, stamping with a printing color, and firing. A batch for a mat enamel in which the borax content is almost entirely replaced by zinc and soda and which retains practically the same expansion and fusibility has the following composition: 29 feldspar, 16 quartz, 10 cryolite, 12.5 soda, 4 saltpeter, 4 fluorspar, 5 antimony oxide, and 9.5 zinc oxide with 5% clay added to the mill. M.V.C.

Modern ground enamels. VIELHABER. *Emailwaren-Ind.*, **16** [40–41] 241–42 (1939).—Batch compositions for ground enamels with minimum borax content are given. M.V.C.

Pickling tanks. VIELHABER. *Beizerei* (in *Emailwaren-Ind.*, **16** [35–36]), **4** [9] 33 (1939).—Changes in pickling tanks have developed slowly. In the earliest publication on enameling by Christoph Erbe, pickling tanks were not used, but a solution of 1 part oil of vitriol and 14 parts water was heated in an iron kettle and poured into the metal vessel to be pickled; the latter was then emptied and plunged into a kettle of hot water. In 1851, Vogelgesang pickled cast iron articles in H_2SO_4 (1:16 or 1:36) in round vats 4 or 5 ft. thick and 3 ft. high made of dry wood free from resin which easily deposits on the cast. The metal was sometimes scoured with sandstone. In 1909 Randau recommended wood tanks coated inside with a lacquer, although at this time quadrangular double wood tanks with an intermediate asphalt layer were also used; natural acidproof stone tanks were hewed from one block and were satisfactory until they cracked; sheet lead linings 3 mm. thick and protected with wood were also used. The best solution of the pickling-tank problem is to line concrete or masonry tanks with acidproof metal, such as bronze or Monel metal. Rubber-lined iron tanks are mentioned. M.V.C.

BOOK

Practical Enamel Expert (Praktische Emailfachmann). RICHARD ALDINGER. Verlag Glashütte, Dresden, 1939. 200 pp. Price 6.80 Rm.—A. gives a very interesting description of enamel practice in Germany. Typical enamel compositions are given and methods of calculation are described with examples. Raw materials are discussed briefly. Many illustrations show the equipment used and its operation. Some of these illustrations are very good while others are quite poorly done. The index is short and incomplete. A.I.ANDREWS

PATENTS

Enameling metallic objects. KARL FRANK (I. G. Farbenind. A.-G.). Ger. 678,450, June 22, 1939 (April 22, 1937); VI/48*c*. 1.—A method is given for enameling metallic objects by applying a foundation coating of enamel. Before or after the fritting on of the foundation coating, metal is precipitated through the pores of the enamel onto the metallic base. D.A.B.

Enameling objects made of cast iron or steel. ERNST RICKMANN. Ger. 678,372, June 22, 1939 (July 2, 1936); VI/48*c*. 1.—The articles are coated with antimony in the usual manner by adding antimony compounds to the pickling acid during the pickling of the metal. D.A.B.

Opaque vitreous enamels. SOC. DE PRODUITS CHIMIQUES DES TERRES RARES AND M. PAQUET. Brit. 513,928, Nov. 8, 1939 (May 5, 1938).

Vitreous enameled sheet and method of production. A. L. MATTHES. U. S. 2,182,132, Dec. 5, 1939 (June 2, 1938).

Glass

Arsenic eliminated from Pyrex chemical glassware. W. C. TAYLOR. *Ind. Eng. Chem., News Ed.*, **14** [2] 23 (1936).—Pyrex chemical glassware formerly contained a few tenths of a per cent of arsenic in order to eliminate small bubbles or seeds. Tests showed that no arsenic was extracted from this glass under ordinary working conditions owing to the extreme resistance of the glass to chemical attack. It seemed desirable, however, to eliminate such an element entirely, and this was finally accomplished after several intermediate stages of reducing its percentage. Arsenic has an influence on color as well as on fining; the present glass, therefore, has a slightly different hue. This is not noticeable in pieces of chemical ware of usual size. In long pieces of tubing or large objects, where the light passes through a foot or more of glass, the color appears somewhat greener than formerly. An incidental advantage brought about by the elimination of arsenic is the increase in transmission of ultraviolet light. F.G.H.

Borax as an accelerator in glassmelting. ROBERT M. CURTS. *Ceram. Ind.*, **29** [6] 445–48 (1937).—Moderate amounts of borax, i.e., 60 to 120 lb. per ton of sand, facilitate melting, increase fabricating speeds, and improve the quality of the resultant glassware. The increase in batch cost is generally considerably less than the production economies afforded through its use. The extent to which melting is facilitated and quality is improved depends largely on the general composition of the batch employed and the specific operating conditions in each glass plant. When particularly large increases in melting rate are required, durability and thermal properties being of secondary importance, the soda is sometimes reduced to a lesser degree. When durability and thermal properties are important it is possible to substitute borax for slightly more than equal amounts of soda. E.J.V.

Colloidal graphite, excellent coating for molds. ERNST GRÜTER. *Glashütte*, **69** [41] 713–14 (1939).—G. discusses the disadvantages of coatings such as oil, soap, beeswax, etc., which have been used heretofore for lubricating molds in the production of cast glass. The use of colloidal graphite as a protection against corrosion and methods of applying aqueous colloidal graphite suspensions are explained. It has the following advantages: (1) molds and machines remain cleaner; (2) the thinness of the coating keeps the shape of the glass more accurately and improves luster; (3) wear on molds from cleaning is minimized; and (4) the refractoriness protects the metal surface of the molds and prolongs their life. M.V.C.

Dielectric loss of glass at high frequencies. H. THURNAUER AND A. E. BADGER. *Jour. Amer. Ceram. Soc.*, **23** [1] 9–12 (1940).

Effect of time and temperature on accelerated chemical durability tests made on commercial glass bottles. FRANK R. BACON AND O. G. BURCH. *Jour. Amer. Ceram. Soc.*, **23** [1] 1–9 (1940).

Effects of humidity on the weathering of glass bottles. VIOLET DIMBLEBY AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **23** [98] 242–52T (1939).—The alkali extracted from the interior of three different brands of 4-oz. medicine bottles by boiling for 5 hr. with water was determined shortly after the bottles were made. Other bottles of each brand were then stored (some with interior as received, some after being washed) for a period exceeding eleven months, some at 25° in specially constructed chambers containing phosphorus pentoxide (and therefore of zero humidity), some in similar chambers at constant relative humidity of 76%, and some, with mouths covered by muslin, in a room subject to normal variations of atmospheric temperature and humidity. Observations of appearance were made throughout the period. At the end, the acidity or alkalinity of the interior and the exterior was determined, and the general durability of the interior was redetermined after a preliminary washing. The durability of bottles stored at zero humidity remained practically unchanged, and no film of crystalline products of weathering was produced. Bottles exposed to a humid atmosphere, either in an enclosed chamber or a room, developed crystalline films (more regular and finer when in the chamber), and the durability of the resulting surfaces was substantially improved. G.R.S.

Electrical resistance under varying conditions of some glasses and porcelains of possible utility for commercial insulators. ERIC SEDDON, J. W. MITCHELL, AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **23** [98] 197–238T (1939).—On 20 different glasses and 9 porcelains (glazed and unglazed) in the form of short rods, systematic measurements were made of the volume resistivity *in vacuo* and of the surface resistivity under varying conditions, including temperature and humidity variations and exposure (for varying periods of time extending to 12 months) to weathering in the atmosphere of a heavily industrialized neighborhood. Measurements were also made on the weathered specimens after the mechanical and chemical cleaning processes were applied to them. The degree of reproducibility of results was studied in detail. Wide variations in the surface resistivity of different specimens was the general experience, whether after exposure to the ordinary atmosphere or to pure water vapor in a closed chamber. The volume resistivity values of different specimens of any one material examined *in vacuo* were in close agreement and remained practically constant with time, and the widely varying resistivities of individual specimens were brought much nearer together when treated in a closed space which could be evacuated, thus showing the dominating effect of the film of moisture or dissolved electrolyte, the various forms of deposit losing potency in the absence of moisture. A wide range of suitable glasses is available to meet the electrical requirements of telephone and telegraph insulators. G.R.S.

Fibrous glass made by a new process. ANON. *Laboratory*, **8** [4] 60 (1937). F.G.H.

Glass composition for opal heat-resisting ware. ANON. *Ceram. Ind.*, **33** [6] 54–55 (1939).—Due to increased wattages in modern illumination and the comparatively high heat developed, most modern illuminating fixtures must be made of glass batches that are heat-resistant. Opal glass is preferred for many of these classes of ware. The most delicate part of compounding batches for this type of glass involves the introduction of opacifiers. No single opacifying agent is normally used alone, but two or more are commonly used together. Those most commonly used are fluorspar, cryolite, and sodium silicofluoride. A good commercial opaque glass cannot be made with fluorspar or sodium silicofluoride alone. If the use of the relatively expensive cryolite is to be minimized, it is necessary to add some material containing alumina. Feldspar is usually recommended. Alumina of itself is not a true opacifier and will not yield an opaque glass except in the presence of fluorine. Fluorspar is not used alone, because if large enough amounts were added to achieve the desired opacity, the lime content would be high enough to cause the glass to become very brittle. Cryolite is a very satisfactory opacifier but is not usually used alone because of its cost. Sodium silicofluoride, although relatively cheap, is not usually used alone because of its narrow range of working temperature and because it becomes necessary to work

the glass at high temperatures to avoid devitrification. The most desirable glass, therefore, is one that contains a combination of these three fluoride-containing materials. L.M.C.

Glass floss from steel silkworms. ANON. *Ceram. Ind.*, **29** [5] 338–43 (1937). E.J.V.

Heat-resisting glassware; tests for quality. S. F. DUNKLEY. *Gas World*, **104** [2690] 172–78 (1936).—D. discusses the properties and tests for heat-resisting glassware to be used in lamps and recommends that it be classified as follows: "A" quality (for the most extreme conditions) which can be immersed without breaking in water having a temperature of 10°C 30 sec. after one hour's operation; "B" quality (for normal conditions of use) which can be immersed in water having a temperature of 55°C 45 sec. after one hour's operation; and "C" quality (for purely decorative illumination glassware) which can be immersed in water having a temperature of 100°C 90 sec. after one hour's operation. Illustrated. F.G.H.

History of the glass industry in the Sudeten district. H. KÜHNERT. *Glastech. Ber.*, **17** [9] 271–75 (1939); see *Ceram. Abs.*, **17** [7] 248 (1938). J.F.H.

How Pyrex brand beakers are made. ANON. *Laboratory*, **10** [1] 2–4 (1938).—The manufacture of Pyrex beakers is briefly described and illustrated. F.G.H.

Opaque quartz. ANON. *Verre & Silicates Ind.*, **10** [28–30] 314 (1939).—Opaque quartz is the name given to opaque silica glass. When the same glass is transparent, it is called quartz glass. The two materials have practically identical physical and chemical properties except for opacity which is due to finely dispersed gas bubbles produced by the raw materials. Quartz glass is made from very pure material, while the opaque variety is made from sand with a minimum silica content of 99.8% and impurities such as water or organic compounds (wood, coal) whose volatility causes the bubbles and holes in the surface. Other impurities have a different effect; sulfates and alkali chlorides favor devitrification. Iron and titanium oxides give black or dark blue spots, and zirconium oxide gives white spots. Certain metals produce fluorescence. The sand should be purified before fusion which is complete at about 1725°; viscosity remains high even at high temperature. Industrial production has been made possible by the development of the electric furnace. Rolling mills and presses are also used for molding, and graphite molds are used for small laboratory pieces. Fused silica reaches a hardness of 7 (Moh's scale) and can be tooled with corundum, silicon carbide, and diamond instruments when cold. Opaque quartz is resistant to neutral and acid agents except hydrofluoric acid and concentrated phosphoric acid above 300°; it has a low expansion coefficient and remarkable insulating properties and can replace the much more expensive quartz glass for laboratory instruments and utensils. Commercial names are Dioxsil, Vitreosil, and Rotosil. M.V.C.

Permeability to moisture of organic surface coatings; use of glass cloth in permeability and adsorption measurements. HENRY FLEMING PAYNE. *Ind. Eng. Chem., Anal. Ed.*, **11** [8] 453–58 (1939).—The value of glass cloth in permeability and adsorption measurements is shown. The permeabilities of four air-drying materials were compared on Patapar and glass cloth and were found to be in agreement. The glass cloth may be coated on both sides, but the coating may be applied to only one side of the Patapar. The permeabilities of two baking materials were determined satisfactorily on glass cloth. This is not possible on the Patapar because of volume changes due to loss and regain of moisture. Illustrated. F.G.H.

Possibility of reducing iron oxide content of molten soda-lime-silica glasses by the action of chlorides. H. MARSHALL BATESON AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **23** [98] 253–64T (1939).—Meltings were made, mainly at 1400°, in platinum, of a glass of the basic composition SiO_2 75.0, CaO 9.2, and Na_2O, 15.8%, to which either 0.1 or 0.2% of iron oxide as Fe_2O_3 in the glass was added; the batch was melted with the addition of ferric, sodium, potassium, or ammonium chloride in amount equivalent, in terms of Cl, to 0.1, 0.2, or 0.4% of the glass. Analysis of the resulting glasses showed that during the melting process iron and chlorine were lost by volatilization, probably as ferric chloride. In no case did the loss of iron oxide reach 25% of the original amount, and, with sodium chloride, in no case did it reach 10%. Although ammonium chloride was the most effective of the reagents in eliminating iron oxide, its use in practice would be of doubtful benefit owing to its tendency to produce coloring effects varying from yellow to brown. G.R.S.

Rhodium mirrors for scientific purposes. M. AUWAERTER. *Jour. Applied Physics*, **10**, 705–10 (1939).—Rhodium has the following advantages as a mirror coating: (1) good mechanical properties, (2) nearly uniform reflectivity, (3) absence of physical or chemical aging, (4) resistance to temperatures up to 430°C, and (5) superior adhesion. A.P.

State of aggregation of glass. R. E. LIESEGANG. *Glastech. Ber.*, **17** [9] 269–71 (1939).—L. briefly discusses various prevalent conceptions of the state of aggregation. Simplification would seem to result if glass were considered to be a mixture of particles varying in size from coarse down to molecular dimensions. The molecular sizes in the viscous condition impart to the coarser aggregates a certain mobility, thus acting as a lubricant. A determination of the aggregate size distribution would be of more importance than a definition of the state of aggregation. It is no mistake to call glass "solid" if the expression "solid state of aggregation" is avoided. Classification of materials as solid, liquid, or gas is too superficial. J.F.H.

Surface-tension measurements on molten glass by a modified dipping cylinder method. C. L. BABCOCK. *Jour. Amer. Ceram. Soc.*, **23** [1] 12–17 (1940).

Tests on the thermal endurance of glass. S. R. SCHOLES. *A.S.T.M. Bull.*, No. 97, pp. 25–26 (March, 1939).—Thermal endurance of glass is specific for any given chemical composition. For all practical purposes the thermal endurance depends inversely upon its coefficient of thermal expansion. Test specimens were cylindrical rods 6 in. in length and of variable diameters. The apparatus used was designed by W. C. Taylor of Corning Glass Works. It is described in detail. The rods were heated to a definite temperature (up to 300°C) and plunged into water at 20°C. The experimental thermal shock values obtained have no relation to the behaviors of different glasses in ware. Two figures. See *Bull. Amer. Ceram. Soc.*, **18** [7] 270–71 (1939). F.F.

Unnecessary loss of raw materials. ZSCHACKE. *Glashütte*, **69** [42] 725–27 (1939).—Appreciable loss of raw materials in glass factories may occur through improper handling and negligence, such as (1) carelessness in the transportation of bulk or unpacked materials such as sand and feldspar; (2) the use of trucks soiled from hauling loads of coal or other materials; and (3) overloading the pushcarts which convey materials to the storage bins; the distance to the bins should be minimized. Finely powdered materials like feldspar are easily scattered during drying if air currents are used. Waste and loss occur because of dampness during storage in the case of potash, soda, and sulfate; borax is also affected. Air-tight storage bunkers are therefore recommended. A certain amount of the materials that come packed in sacks is lost when the sacks are not completely emptied. Glass plants in North America have installed special machines for beating out the contents of sacks. M.V.C.

Versatile glass. ANON. *Laboratory*, **8** [3] 34–37 (1936).—A brief history of glass is given. Illustrated. F.G.H.

PATENTS

Air filter. GAMES SLAYTER (Owens-Illinois Glass Co.). Can. 384,159, Sept. 19, 1939 (June 24, 1937). G.M.H.

Apparatus for:

Assembling two tubular glass elements. JENAER GLASWERK SCHOTT & GEN. Fr. 838,895, June 3, 1938. D.A.B.

Bending glass sheets. O. H. PADDOCK (Libbey-Owens-Ford Glass Co.). U. S. 2,182,448, Dec. 5, 1939 (Nov. 18, 1937).

Cooling glassware. W. K. BERTHOLD (Hartford-Empire Co.). U. S. 2,182,167, Dec. 5, 1939 (Feb. 17, 1938).

Drawing quartz tubes or tubes of glass high in silica content. "OSA" PARTICIPATIONS INDUSTRIELLES SOC. ANON. Fr. 835,128, March 11, 1938. D.A.B.

Making safety glass. J. H. SHERTS AND B. J. DENNISON (Pittsburgh Plate Glass Co.). U. S. 2,182,358, Dec. 5, 1939 (Dec. 22, 1934; Jan. 20, 1938).

Manufacturing containers such as pharmaceutical ampoules, etc., by drawing glass tubes. J. SZANTO. Fr. 838,788, June 2, 1938. D.A.B.

Manufacturing ground and polished glass bands. PILKINGTON BROS., LTD. Fr. 835,287, March 15, 1938. D.A.B.

Manufacturing and winding glass threads. "OSA" PARTICIPATIONS INDUSTRIELLES SOC. ANON. Fr. 827,164, Sept. 27, 1937. D.A.B.

Winding glass fibers. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Fr. 836,664, April 15, 1938. D.A.B.

Apparatus and process for:

Grinding and polishing glass bands. PILKINGTON BROS., LTD. Fr. 834,902, March 7, 1938. D.A.B.

Manufacturing fibrous materials from glass fibers. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Fr. 834,302, July 15, 1937. D.A.B.

Manufacturing ground and polished glass bands. PILKINGTON BROS., LTD. Fr. 835,036 and 835,037, March 9, 1938. D.A.B.

Manufacturing small or lamellar plates and their products. CORNING GLASS WORKS. Fr. 838,377, May 24, 1938. D.A.B.

Manufacturing spun glass. F. POLLAK AND F. NEUMANN. Fr. 834,467, March 1, 1938. D.A.B.

Tempering glass. CORNING GLASS WORKS. Fr. 836,978, April 22, 1938. D.A.B.

Tempering glass objects, plates, etc. N. DRUFUCA ROMANIN. Fr. 849,306, Jan. 23, 1939. D.A.B.

Treating glass objects. CORNING GLASS WORKS. Fr. 849,721, Feb. 1, 1939. D.A.B.

Assembling pieces in glass, ceramic material, vacuum tubing, etc. C. LORENZ A.-G. Fr. 849,391, Jan. 25, 1939. D.A.B.

Coating glass with metal. R. D. SMITH (Corning Glass Works). Can. 384,117, Sept. 19, 1939 (Oct. 14, 1937); see *Ceram. Abs.*, **18** [8] 208 (1939). G.M.H.

Composite glass for all uses and process of manufacture. H. SOMIGLIANA. Fr. 849,743, Feb. 1, 1939. D.A.B.

Decorating glass articles. SOC. ANON. HOLOPHANE. Fr. 836,412, Sept. 27, 1937. D.A.B.

Distribution of glass in molten state. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Fr. 836,013, April 1, 1938. D.A.B.

Electric glass furnace. J. H. THOMAS (Owens-Illinois Glass Co.). U. S. 2,181,030, Nov. 21, 1939 (Dec. 30, 1936; renewed April 17, 1939).

Electric insulator. J. C. HOSTETTER AND J. T. LITTLETON (Corning Glass Works). Can. 384,120, Sept. 19, 1939 (June 13, 1938); see "Insulator—," *Ceram. Abs.*, **18** [1] 20 (1939). G.M.H.

Electrodes to be employed for heating baths such as molten glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Fr. 849,510, Aug. 5, 1938. D.A.B.

Forming machine for glassware. T. F. PEARSON (Crown Cork & Seal Co., Inc.). U. S. 2,180,766, Nov. 21, 1939 (Jan. 11, 1937).

Frangible block mounting. S. F. COX (Pittsburgh Plate Glass Co.). U. S. 2,182,373, Dec. 5, 1939 (Aug. 10, 1938).

Glass-ampoule manufacture. HARRY RICHTER (Kimble Glass Co.). Can. 384,597, Oct. 10, 1939 (Aug. 29, 1938; in U. S. Sept. 14, 1937). G.M.H.

Glass article tempering method. J. T. LITTLETON AND R. K. DAY (Corning Glass Works). Can. 384,877, Oct. 31, 1939 (May 25, 1938; in U. S. June 24, 1937). G.M.H.

Glass block joining method. JAMES F. HYDE (Corning Glass Works). Can. 384,874, Oct. 31, 1939 (Nov. 25, 1937); see "Joining—," *Ceram. Abs.*, **17** [6] 218 (1938). G.M.H.

Glass-block trimmer. C. E. HAWK (Owens-Illinois Glass Co.). U. S. 2,181,810, Nov. 28, 1939 (Jan. 21, 1939).

Glass blocks, etc. E. GENTIL AND A. GENTIL. Fr. 835,525, Sept. 3, 1937. D.A.B.

Glass-coated screen. J. T. LITTLETON (Corning Glass Works). Can. 384,878, Oct. 31, 1939 (Nov. 9, 1938; in U. S. Jan. 6, 1938). G.M.H.

Glass die or form made of unalloyed low carbon ingot steel. GLASWERKE RUHR A.-G. Ger. 678,950, June 29, 1939 (April 22, 1936); VI/32*a*. 7. Addition to Ger. 637,861 (*Ceram. Abs.*, **16** [10] 300 (1937)).—A die or form to be used for the production of blown glass articles is produced from unalloyed low carbon ingot steel according to Ger. 637,861. The surface coming into contact with the molten glass is strengthened with a 1 to 2% addition of carbon. D.A.B.

Glassmelting furnace. EUGENE C. SULLIVAN (Corning Glass Works). Can. 384,119, Sept. 19, 1939 (May 17, 1938); see *Ceram. Abs.*, **18** [8] 209 (1939). G.M.H.

Glass piping for sanitation conduits. SOC. DES PRODUITS CÉRAMIQUES DE SARS-POTERIES S. à R. L. Fr. 834,773, March 4, 1938. D.A.B.

Glass plates to be used for construction of translucent partitions and covers. FIDENZA SOC. ANON. VETRARIA. Fr. 836,558, April 13, 1938. D.A.B.

Glass products for electrical purposes. H. GEORGE. Fr. 834,810, Aug. 14, 1937. D.A.B.

Glass-sheet manufacture. BELLE VERNON (American Window Glass Co.). Can. 384,676, Oct. 17, 1939 (June 24, 1938; in U. S. April 29, 1938). G.M.H.

Glass stopcock barrel manufacture. C. G. ANASTOR (Kimble Glass Co.). Can. 384,596, Oct. 10, 1939 (Aug. 25, 1938; in U. S. Aug. 28, 1937). G.M.H.

Glass-tempering apparatus. HARRY R. KIEHL (Corning Glass Works). Can. 384,118, Sept. 19, 1939 (Dec. 4, 1937; in U. S. Feb. 23, 1937). EVAN J. LEWIS (Corning Glass Works). Can. 384,875, Oct. 31, 1939 (March 19, 1938; in U. S. April 22, 1937). G.M.H.

Glass textile high voltage insulated cable. L. W. W. MORROW (Corning Glass Works). Can. 384,879, Oct. 31, 1939 (Nov. 9, 1938; in U. S. Jan. 25, 1938). G.M.H.

Glass tubular elements for construction purposes. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Fr. 848,079, Dec. 27, 1938. D.A.B.

Glassware annealing lehr. F. E. DORSEY (Hartford-Empire Co.). U. S. 2,182,173, Dec. 5, 1939 (Aug. 10, 1937).

Glassware conveyer. D. E. GRAY (Corning Glass Works). Can. 384,876, Oct. 31, 1939 (March 29, 1938; in U. S. June 8, 1937). G.M.H.

Glassware takeout and fire-finishing device. W. K. BERTHOLD (Hartford-Empire Co.). U. S. 2,182,166, Dec. 5, 1939 (Aug. 5, 1937).

Hardening glass plates. FRITZ ECKERT. Ger. 678,870, June 29, 1939 (Jan. 24, 1938); VI/32*a*. 30.—Glass plates which are to stand or to be suspended vertically are hardened, for the purpose of producing a safety glass, by heating the glass plate until the beginning of the softening point. The plate is withdrawn vertically from the annealing furnace and is sharply cooled down superficially on both sides before its withdrawal from the furnace is checked. D.A.B.

Heat treatment for glass. H. W. HESS. U. S. 2,180,737, Nov. 21, 1939 (Jan. 2, 1936).

Hollow glass brick. H. FRIEDRICH. Fr. 836,263, April 6, 1938. D.A.B.

Hollow glass building block. BENJAMIN F. HAZELTON, JR. (Owens-Illinois Glass Co.). Can. 383,994, Sept. 12, 1939 (Sept. 3, 1937). W. P. ZIMMERMAN AND M. K.

HOLMES (Owens-Illinois Glass Co.). Can. 383,995, Sept. 12, 1939 (Sept. 27, 1937; in U. S. April 27, 1937). G.M.H.

Household articles of glass such as glasses and containers. H. L. FORGAARD. Fr. 835,845, March 28, 1938. D.A.B.

Incandescent lamp. D. K. WRIGHT (Canadian General Electric Co., Ltd.). Can. 384,237, Sept. 26, 1939 (Oct. 22, 1936). G.M.H.

Insulating objects with glass thread. OSCAR GOSSLER GLASGESPINSTFABRIK G.M.B.H. Fr. 829,904, Nov. 25, 1937. D.A.B.

Lamellar glass. G. DESAGNAT. Fr. 850,029, Feb. 8, 1939. D.A.B.

Laminated glass article. BOZETECH CHESTMIR BREN (Canadian Industries, Ltd.). Can. 383,979, Sept. 12, 1939 (Dec. 11, 1936). G.M.H.

Manufacture of amorphous quartz products. M. HAUSER. Fr. 827,500, Oct. 5, 1937. D.A.B.

Manufacture of artificial mineral fibers, particularly glass fibers with rough surfaces. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Fr. 849,842 and 849,843, Feb. 4, 1939. D.A.B.

Manufacture of bulbs. COMPAGNIE DES LAMPES. Fr. 835,874, March 29, 1938. D.A.B.

Manufacture of laminated glass. F. L. BISHOP (American Window Glass Co.). U. S. 2,180,625, Nov. 21, 1939 (May 6, 1933).—In the manufacture of laminated glass, the steps comprise heating a solution comprising a strengthening material and a solvent therefor, heating a glass sheet, forming a layer of the heated strengthening material on the heated glass sheet, the glass sheet and the strengthening material being heated to a temperature sufficient to drive off a portion of the solvent or other liquid in the solution, drying the layer of strengthening material, and thereafter uniting the coated glass sheet to a second similarly coated glass sheet with the layer of strengthening material therebetween.

Manufacture of mineral wool. DEUTSCHE EISENWERKE AKT.-GES. Brit. 514,243, Nov. 15, 1939 (April 16, 1938).

Manufacture of threads, cloths, etc., in glass fibers and fibrous asbestos. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Fr. 838,216, May 21, 1938. D.A.B.

Manufacturing devitrified glass. J. R. RIDEAU AND A. M. DUCRET. Fr. 834,307, July 15, 1937. D.A.B.

Manufacturing etched window glass. G. DESAGNAT. Fr. 850,025, Feb. 8, 1939. D.A.B.

Manufacturing glass articles, etc. SOC. DES PRODUITS CÉRAMIQUES DE SARS-POTERIES S. à R. L. Fr. 835,423, March 18, 1938. D.A.B.

Method and automatic device for sealing glass block halves together. J. R. HOGE, L. D. SOUBIER, AND L. O. MANKIN (Owens-Illinois Glass Co.). U. S. 2,182,986, Dec. 12, 1939 (Oct. 31, 1936).

Method and means for forming hollow glassware. UNITED GLASS BOTTLE MFRS., LTD., AND C. S. STAFFORD. Brit. 513,945, Nov. 8, 1939 (April 22, 1938).

Mirror with protective facing. COMPAGNIES RÉUNIES DES GLACES ET VERRES SPÉCIAUX DU NORD DE LA FRANCE. Fr. 836,776, Oct. 7, 1937. D.A.B.

Multicolored one-piece glass shields. G. AVRIL FILS. Fr. 834,559, March 2, 1938. D.A.B.

Objects in glass which have been subjected to high pressures and a support for these glass objects. SENDLINGER OPTISCHE GLASWERKE G.M.B.H. Fr. 849,571, Jan. 27, 1939. D.A.B.

Ophthalmic lens. M. A. LAABS (American Optical Co.). Can. 384,091, Sept. 19, 1939 (Aug. 15, 1938). G.M.H.

Ophthalmic lens and process of making. O. G. HAUSSMANN. U. S. 2,182,537, Dec. 5, 1939 (Oct. 15, 1937).

Ophthalmic lenses, series of the lenses, and method of making. E. D. TILLYER (American Optical Co.). U. S. 2,180,887, Nov. 21, 1939 (March 31, 1937).

Producing glasses with low thermal expansion. CORNING GLASS WORKS. Ger. 679,451, July 13, 1939 (Feb. 18, 1936); VI/32*b*. 1.—A method is given for producing glasses with low thermal expansion which contain silicon dioxide and alkali oxide in addition to boric acid. The content of silicon dioxide is between 75 and 87%, that of the alkali oxide is between 0.5 and 2.5%, and the amount of lithium compounds added to the mass is such that the alkali consists, at the most, of one-third lithium oxide. D.A.B.

Producing glass tubes or cylinders. D. E. GRAY (Corning Glass Works). Ger. 679,540, July 13, 1939 (April 2, 1937); VI/32*a*. 24.02.—Glass tubes or cylinders of predetermined length and diameter are produced by means of an apparatus with an outlet opening at the base and by means of a pin or rod which is arranged in the same axis as the outlet opening. The pin is introduced into the stream of glass escaping from the outlet of the apparatus or receptacle and is moved with the stream of glass until it is completely covered with glass. The pin covered with glass is removed from its motivating unit so that it sinks down into the glass stream because of its weight; the pin together with its surrounding glass covering is removed from the stream of glass and placed in an annealing apparatus; after the glass is cooled and the ends of the glass covering are cut, the glass is removed from the pin as the completed glass tube or cylinder. D.A.B.

Producing ornamental glass. FRANK DEAN PARKINSON. Ger. 677,065, May 25, 1939 (June 25, 1937); VI/32*b*. 5.—The glass surface provided with prominences is colored in such a manner that the surfaces of the prominences, when viewed from one side, possess one color while the other surface of the same prominence is not colored or is colored in some other shade. Viewing of the glass from different angles would result in a schiller-like play of colors which is produced by light falling on the prominences. D.A.B.

Recovery of wastes from glass grinding and polishing operations. R. R. MCGREGOR (N. S. Garbisch). U. S. 2,182,384, Dec. 5, 1939 (April 13, 1937).—A process of producing relatively pure substantial iron-free mixtures of intimately associated and very finely divided silica and glass suitable for use as a combined source of silica and cullet in a glass batch, as a substitute for both ground flint and feldspar in a ceramic body, and similar purposes, from waste sand produced in the grinding of the surface of glass plates with sand of glass-batch purity, the waste sand containing substantial amounts of iron added by the grinding operations and being of a particle size such that at least about 90% of it will pass through a screen of about 325-mesh, comprises treating the sand sludge while fresh from the grinding operation by means of a magnetic separator to take out metallic iron particles, treating it with a solution consisting of a strong mineral acid and water, the acid being of a concentration of not substantially greater than 10% and being in an amount sufficient to take out substantially all of the free iron and iron compounds remaining in the wastes, washing out the dissolved iron, and freeing the wastes of excess water.

Refractory objects or materials made of mineral wool or slag wool and a binding material. J. EICKE. Fr. 848,393, Jan. 2, 1939. D.A.B.

Screen consisting of glass threads to be used as a separator for electric accumulators. COMPAGNIES RÉUNIES DES GLACES ET VERRES SPÉCIAUX DU NORD DE LA FRANCE. Fr. 49,358, Oct. 25, 1937; addition to Fr. 810,810. D.A.B.

Sheet glass manufacturing apparatus. JOSEPH H. LEWIS (Blue Ridge Glass Corp.). Can. 384,852, Oct. 31, 1939 (April 8, 1938; in U. S. Sept. 28, 1937). G.M.H.

Skimming device for glass tanks or furnaces. T. F. PEARSON (Crown Cork & Seal Co., Inc.). U. S. 2,180,767, Nov. 21, 1939 (April 29, 1937).

Special insulated armature in drawn molded glass. P. GALLOO. Fr. 828,351, Oct. 27, 1937. D.A.B.

Spinning together a metal and a ceramic article. G. J MEYERS, JR. (General Electric Co.). U. S. 2,180,902,

Nov. 21, 1939 (Aug. 24, 1937).—The process of spinning an aluminum reflector onto a glass globe comprises heating the reflector to substantially expand the reflector without injuring its reflecting surface, assembling the reflector and globe, and turning the assembled unit while spinning the flange of the reflector over a coöperating flange on the glass globe.

Trial lens. K. N. OGLE (Trustees of Dartmouth College). U. S. 2,183,028, Dec. 12, 1939 (March 7, 1936).

Vacuum tight ceramic articles. HANS PULFRICH (Patent-Treuhand Ges. für elektrische Glühlampen m.b.H.). Ger. 678,419, June 22, 1939 (Jan. 9, 1937); VI/80*b*. 23.20.—Vacuum tight ceramic articles to be fused onto soft glass consist of 20 to 35% beryllium oxide, 80 to 65% magnesium oxide, and an addition of titanium dioxide up to 2%. D.A.B.

Winding glass threads. SCHLESISCHE SPIEGELGLAS MANUFAKTUR CARL TIELSCH G.M.B.H. Fr. 827,219, Sept. 29, 1937. D.A.B.

Structural Clay Products

Brick re-laying in Dayton. J. F. HALE. *Dependable Highways*, No. 164, pp. 9–11 (1939).—Dayton, Ohio, brick pavement renovation programs are described and illustrated. P.S.D.

Comparison of standard tests on building brick by two laboratories. W. J. KREFELD AND J. W. MCBURNEY. *A.S.T.M. Bull.*, No. 96, pp. 7–11 (Jan., 1939).—The comparisons were made to determine whether two companies, working independently on the same or comparable samples, would obtain the same results if the current standards for testing brick were followed. The current water-absorption tests are satisfactorily accurate and reproducible. The compressive-strength test is unsatisfactory in comparison with the water-absorption test. Six tables. F.F.

Inventory taking of structural clay products research programs. HARRY C. PLUMMER AND FREDERICK HEATH, JR. *Bull. Amer. Ceram. Soc.*, **18** [12] 466–67 (1939).

Recent brick pavement improvements. MARK CHAMBERS. *Dependable Highways*, No. 164, pp. 3–8 (1939).—C. describes cost analysis, construction organization, and details of construction for Battle Creek, Michigan, brick paving projects. Illustrated. P.S.D.

PATENTS

Brick-bond gauge. JOSEPH PALMER. Can. 383,933, Sept. 12, 1939 (May 19, 1938); see *Ceram. Abs.*, **18** [3] 74 (1939). G.M.H.

Building wall structure. L. E. WILLSON (Brick-V-Neer Sales Co.). U. S. 21,278, Nov. 21, 1939 (Sept. 12, 1939); reissue of 2,093,262, Sept. 14, 1937.

Facing brick for regenerators and facings requiring this kind of brick. STEIN- UND THON INDUSTRIEGES. "BROHLTHAL." Fr. 836,511, April 12, 1938. D.A.B.

Hollow brick. KARL A. JOHNER. Ger. 677,922, June 8, 1939 (Nov. 14, 1936); V/37*b*. 1.01.—Brick design is given. D.A.B.

Refractories

Action of alkalis on refractory materials: XI, Experiments on the alterations in strength when refractory materials are exposed to potassium chloride vapor at 1000°C. F. H. CLEWS, H. M. RICHARDSON, AND A. T. GREEN. *Iron & Steel Inst. Special Rept.*, No. 26, pp. 397–400 (1939); see *Ceram. Abs.*, **18** [8] 211 (1939).

Action of slags on refractory materials: II, Corrosive action of lime on aluminous, fire-clay, and silica brick. W. HUGILL, R. L. AINSWORTH, AND A. T. GREEN. *Iron & Steel Inst. Special Rept.*, No. 26, pp. 351–57 (1939); see *Ceram. Abs.*, **18** [8] 211 (1939).

Beneficiating ferruginous bauxites through chlorination. COLIN G. FINK AND V. S. DE MARCHI. *Trans. Electrochem. Soc.*, **74**, 469–94 (1938).—There is little or no application for the high-iron bauxites due to lack of a cheap method of separating the aluminum oxide from the iron oxide. It was found that if the iron oxide in the bauxite is first converted into the sulfide and is then chlorinated, 90% of the iron oxide, over 50% of the titanium dioxide, and about 14% of the silica present will be eliminated as chlorides, carrying along only about 9% of the alumina originally contained in the bauxite. Illustrated. F.G.H.

Burning of waste liquors in the Kraft and soda-paper industries. L. S. WILCOXSON. *Trans. Amer. Soc. Mech. Engrs.*, **60** [1] 25–34 (1938).—The furnace is entirely water-cooled and employs fully studded construction, the tubes being 3.25 in. in outside diameter on 6 in. centers. The studded wall construction is covered with plastic chrome ore; this refractory was chosen after exhaustive experiments as being that most suited because of the neutral characteristics of chrome ore in withstanding the chemical action of the smelt, which has a melting point between 1500° and 1650°F, depending on the actual percentages of various sodium salts present. The sodium salts of the smelt have a decidedly corrosive action not only on the refractory but also on steel at elevated temperatures. This corrosive action takes place in the furnace as constructed and originally put into operation; within a relatively short period of operation, however, an equilibrium condition is reached between the molten smelt, refractory, and metal of the studs, which, when once reached, is (as far as experience to date would indicate) maintained indefinitely. The side walls of the furnace taper somewhat from the top to the bottom, the tubes of the side walls being expanded into a common lower header running lengthwise at the center of the bottom of the furnace. The hearth is formed on the bottom horizontally inclined sections of these tubes of a solid mass of plastic chrome ore, the contour of all portions of the surface sloping toward the tap hole, located at the center of the front wall at the bottom to insure continuous and complete tapping of the molten smelt. Illustrated. F.G.H.

Deformation of insulating firebrick under load. C. L. NORTON, JR., AND V. J. DUPLIN, JR. *Jour. Amer. Ceram. Soc.*, **23** [1] 22–25 (1940).

Design of high-capacity boilers. JOHN VAN BRUNT. *Trans. Amer. Soc. Mech. Engrs.*, **60** [6] 485–92 (1938).—Refractory requirements for furnace side walls and bottoms are discussed. Illustrated. F.G.H.

Evolution of the electric arc furnace in metallurgy. R. BERR. *Usine*, **48** [36] 23 (1939).—The type of electric arc furnaces is still based on the Heroult principle. Improvement has been mainly in the development of refractories for the lining and the arch which have to stand 3000° to 3500°C. Silica brick are preferred as they can now be produced at reasonable cost. Chrome-magnesite brick have lately been used for the arch with good results. Bottoms and supports are made of siliceous or magnesite products; these, however, have not yet sufficient resistance to repeated shutting down and heating up; mixing them with dolomite gives a good refractory resistance. Three principal types of electrodes used are amorphous carbon, synthetic graphite, and continually built-up electrodes. Charging devices such as those for the open-hearth furnace are not satisfactory; charging near the bottom is mechanically difficult, and charging through the arch makes it always necessary to have a spare ready in case of damage. No satisfactory solution yet exists. Because of their great advantages in improved steel quality, diminished oxidation, and diversity of products (especially for alloy steels), electric arc furnaces are used more and more. In Scandinavia, they are used for the

reduction of ore in making pig iron, the reduction being made with coke with part of the ore added in powder form. Energy consumption is about 2300 kw.-hr. per ton for acid open-hearth Fe and 2800 to 3000 kw.-hr. for pig Fe rich in Si. The gas produced in this process is rich in CO and has about 2500 cal. per m.³ heating value. M.H.

Experimental open-hearth furnace. HAROLD K. WORK AND MAURICE H. BANTA. *Metal Progress*, **35** [5] 479–83 (1939).—The development is described of a small experimental open-hearth furnace, so constructed that it will accommodate a 2700-lb. heat. The results of numerous heats indicate definitely that the physical properties of steel made in this small furnace are comparable, in general, to those produced in large mill furnaces. At present the furnace is manually controlled; equipment is provided, however, for indicating and recording information such as roof temperature, temperature of air from recuperator, gas flow, air flow, and furnace pressure. Installation of equipment for fully automatic control, including air-fuel ratio, roof temperature, and furnace pressure, is being considered. The furnace furnishes a possibility for studying refractories under conditions approaching mill service. A detailed drawing of the furnace is included. J.J.H.

Factors influencing the durability of chrome-magnesite brick in basic open-hearth furnaces. W. HUGILL AND A. T. GREEN. *Iron & Steel Inst. Special Rept.*, No. 26, pp. 189–99 (1939); see *Ceram. Abs.*, **18** [2] 51 (1939).

Fundamentals of the design of cracking furnaces. A. L. BAKER, J. H. RICKERMAN, AND W. E. LOBO. *Trans. Amer. Soc. Mech. Engrs.*, **60** [7] 521–30 (1938).—Refractory requirements are discussed in detail. Illustrated. F.G.H.

Glass-tank refractories. W. J. REES. *Trans. Brit. Ceram. Soc.*, **38** [9] 522–28 (1939).—R. concludes that (1) well-fired dense aluminous blocks are desirable for modern high-temperature tank furnaces; (2) dense, well-fired sillimanite blocks are more resistant to attack by the molten glass than aluminous fire-clay blocks; (3) there are likely advantages in the presence of free alumina in the matrix of the sillimanite tank block batch; (4) a dense structure obtained by good grading and a suitable method of making, followed by high-temperature firing with soaking at the top temperature, is essential for any tank block other than fusion-cast, whether of fire clay or sillimanite; (5) a high-firing temperature is essential for obtaining the best service from sillimanite tank blocks, i.e., at least 1500°C; and (6) the hard-fired, dense, "live" type of sillimanite block may give service approaching that of fusion-cast blocks. See "Use—," *Ceram. Abs.*, **18** [9] 247 (1939). R.A.H.

High-temperature refractories. JOHN D. SULLIVAN. *Metal Progress*, **36** [4] 500–501 (1939).—S. briefly describes the development and improvement of special high temperature refractories. J.J.H.

Insulation. J. B. AUSTIN. *Metal Progress*, **36** [4] 501–502 (1939).—A. points out the relative inactivity in the development of insulation for temperatures above 2000°F; there has been marked advance in insulation for temperatures below 2000°F during the past year. Included in the low temperature insulation materials are the numerous kinds of mineral wool. J.J.H.

Protection of refractory linings of boilers, kilns, furnaces, etc., with a corundum layer. ANON. *Werkstatt & Betrieb*, **72** [17–18] 243–44 (1939).—A mixture of 60% emery, silicon carbide, or alundum and 40% water glass (42° Bé) with additional water is used as a protective covering on refractory lining. The viscosity should be similar to that of a syrup. A brush with coarse bristles is the most suitable. The lining must be absolutely dry before the coat is applied. For basic slags or material, a composition of 75% abrasive and 25% clay with added water is recommended. J.M.N.

Refractories of the alumina-silica series. FRED A. HARVEY. *Trans. Electrochem. Soc.*, **75**, 99–121 (1939).—Refractories are made of alumina-silica comprising practically the entire range of compositions of the series from 100% silica to 100% alumina. The equilibrium diagram for pure alumina and silica is briefly discussed. The properties of silica brick and the effects of accessory oxides are mentioned. Following through the series in the order of increasing proportions of alumina in the commercial refractories available, H. discusses their properties and recent improvements. The importance and significance of test methods are given. Illustrated. F.G.H.

Refractories in progress. J. M. MCKINLEY. *Metal Progress*, **36** [4] 499–500 (1939).—McK. discusses the gradual decrease of the old trial-and-error methods to improve the service of refractories. He points out that the fundamentals of our present specifications must be recognized as more or less inadequate and firebrick users as well as producers have a difficult task ahead of them in correlating service conditions with some type of control testing. J.J.H.

Refractoriness-under-load test: VI, Behavior of refractory materials at high temperatures under increasing load. F. H. CLEWS, W. F. FORD, AND A. T. GREEN. *Iron & Steel Inst. Special Rept.*, No. 26, pp. 467–75 (1939); see *Ceram. Abs.*, **18** [8] 214 (1939).

Relation of low weight to the physical properties of furnace refractories. C. L. NORTON. *Trans. Electrochem. Soc.*, **75**, 123–30 (1939).—The weight and porosity of insulating firebrick are discussed in relation to their thermal conductivity, heat capacity, spalling, cold crushing strength, hot load-bearing capacity, permeability, and resistance to slag erosion and abrasion. The weight of a furnace refractory is a direct indication of its thermal conductivity and heat capacity, and the lower the weight, the more efficient is the refractory in the saving of fuel. Low weight is not directly related to shrinkage or use limit or the ability to carry load at high temperatures; it is related somewhat to the cold strength of the refractory, but this is not usually of great importance. The most desirable refractory, therefore, is the lightest one which can stand the service temperature required without undue shrinkage and which can provide sufficient resistance to the spalling, slagging, and erosion conditions connected with the individual installation. Illustrated. F.G.H.

Rotary furnaces. A. J. G. SMITH. *Elec. Rev.*, **125** [3229] 494 (1939).—The design and construction of a small rotary furnace for heating metal parts to 550°C is briefly described. Three figures. J.L.G.

Scorification and destruction of refractory materials in Martin furnaces. A. M. RUBAN. *Sovet. Met.*, **10** [1] 38–44 (1938); abstracted in *Chem. Zentr.*, **1939, II,** 1737–38.—During the first 20 smeltings in Martin furnaces crystallization and a further tridymite formation occur. This period contributes to the physical and chemical stability of the refractory lining of the furnace. The destruction of the block by the formation of porous spots is divided into two stages: (1) the soiling of the gray zone with particles of coal dust, and (2) a washing out of the tridymite by fluxes. Both processes occur simultaneously and are intensified by high temperature. The assumption of different investigators that a temperature of 1470° exists in the boundary between the gray and black zones was not confirmed by R., as blocks with a gray zone measuring 160 to 180 mm. are employed at the Kirov Works. In such cases, with the smallest temperature gradation of only 3° for 1 mm. block length, a temperature of 1950° must prevail on the side of the crown next to the fire, which is not likely. The mechanical destruction of the Dinas and magnesite block can be greatly reduced by the use of suitable heat insulators. Moreover, heat insulation permits a more complete crystallization of tridymite and also a widening of the black and brown zones. The scorification and the zone structure have a similar character in Dinas and magnesite block. The structure and extent of the diffusion of the fluxes, e.g., CaO and SiO_2, are explained not only by the temperature conditions which exist in the different zones in the block but also by the chemical behavior of the refractory toward one or other of the diffusing oxides. The strongly basic CaO reaches the greatest concentration in the third zone of refractory Dinas material; the acid flux (SiO_2) diffuses deepest in magnesite block and reaches its greatest concentration

in the third zone. It is assumed that physicochemical processes, which also include reactions in a solid state, take place during the formation of the zones in magnesite and Dinas materials. M.V.C.

Steam and power in the bleached sulfite pulp mill. W. R. GIBSON. *Trans. Amer. Soc. Mech. Engrs.*, **55** [3] 59–61 (1933).—The possibilities of combining the operations of a pulp mill and a sawmill are stated; the sawmill has a surplus of waste wood for fuel and of low-grade wood for pulping and usually exhausts large quantities of steam to the atmosphere. Perhaps the greatest difficulties in operation of such a plant at high ratings arise from the hog-fuel ash attacking the refractories, forming a slag that builds up on the boiler and the superheater tubes so as to finally bridge across the tubes. The effect on refractories is due to a combination of factors, all tending to lower the fusion point of the firebrick. Some of these are (1) high moisture content, (2) high alkaline content, (3) the presence of tannic acid, and (4) the presence of acetic acid. The high CO_2 possible with this fuel appears also to be a factor, and a most destructive action is sometimes set up by carbon monoxide due to local lack of oxygen. Cases of slag fusion forming masses 3 to 4 ft. thick have been cured by the admission of secondary air at the proper point; in other cases, firebrick would disintegrate without visible evidence of heat, apparently due to pockets of CO. Sodium sulfate occasionally forms due to combination of alkaline ash from hog fuel and sulfur from fuel oil burned together or separately in the same furnace. When this happens, even high-grade firebrick will run like molasses, and the engineer may find more damage to his setting in a few hours than that which normally would take place in months. F.G.H.

Tridymitization of silica brick. A. A. CHADEYRON AND W. J. REES. *Iron & Steel Inst. Special Rept.*, No. 26, pp. 205–10 (1939); see *Ceram. Abs.*, **17** [2] 75 (1938).

PATENTS

Brick to be used in the production of furnace ceilings, walls, etc. M. H. DETRICK Co. Ger. 678,696, June 29, 1939 (Jan. 21, 1935); V/24*k*. 5.02.—Brick design is given. D.A.B.

Extracting bauxite and other aluminum-containing substances. RUDOLF SCHOLDER. U. S. 2,181,669, Nov. 28, 1939 (May 10, 1937).—A process for obtaining alumina from aluminiferous materials comprises decomposing the aluminiferous material by a decomposing liquor containing alkali-metal oxide and at least one alkali-metal halide of the group composed of sodium chloride, sodium bromide, potassium chloride, and potassium bromide, the ratio of the alkali-metal halide and the alkali-metal oxide being approximately 1:3, and producing thereby an aluminate liquor, the alkali-metal oxide being present in the liquor in such proportions as to maintain a ratio of it and the aluminum oxide of between approximately 1.5:1 and 1.1:1.

Furnace construction. G. E. SEIL (E. J. Lavino & Co.). U. S. 2,180,969, Nov. 21, 1939 (Feb. 15, 1939).

Heat-insulating linings. ANCIENS ÉTABLISSEMENTS MICHEL ET MARCHAL. Fr. 848,296, June 30, 1938. D.A.B.

Manufacturing articles of hard cast refractory material and their application to high-temperature furnaces. M. MANNHEIMER. Fr. 849,462, July 30, 1938. D.A.B.

Manufacturing refractories. ÖSTERREICHISCH AMERIKANISCHE MAGNESIT AKT.-GES. Brit. 514,125, Nov. 15, 1939 (April 28, 1937).

Preparation of ceramic insulating compounds. COMPAGNIE FRANÇAISE POUR L'EXPLOITATION DES PROCÉDÉS THOMSON-HOUSTON. Fr. 848,128, Dec. 29, 1938. D.A.B.

Producing fireproof material from chromite and natural products containing magnesium orthosilicates such as olivine. VICTOR MORITZ GOLDSCHMIDT. Ger. 677,322, May 25, 1939 (May 27, 1936); VI/80*b*. 8.04.—Fifty to ninety parts by weight of chromite are mixed with about 10 to 40 parts by weight of material abundant in magnesium orthosilicates, and the mixture is solidified in the usual manner after transformation into the forms for producing the products of desired shapes. D.A.B.

Refractory brick. R. J. TUGWOOD (Metallfrax Akt.-Ges.). Brit. 513,972, Nov. 8, 1939 (April 25, 1938.)

Tubular unit for boiler walls. T. E. MURRAY, JR. U. S. 2,181,950, Dec. 5, 1939 (March 21, 1936).

Terra Cotta

New stoneware in the electrochemical field. PERCY C. KINGSBURY. *Trans. Electrochem. Soc.*, **75**, 131–39 (1939).—Highly vitrified clay products, due to their almost complete resistance to corrosion, occupy a unique position as structural materials for electrochemical equipment. Stoneware, the most important of these ceramic bodies for chemical purposes, is fabricated into every kind of industrial equipment and is available in shapes weighing up to a ton or more. The physical properties of an average grade of this ware are given and used as a basis for its comparison with bodies recently developed for withstanding exceptional conditions of mechanical and thermal stress. A very dense body is used for stoneware cells for the Moebius and Thum silver-gold parting processes. For equipment for heat exchangers, etc., a large part of the silicate of ordinary stoneware has been replaced by silicon carbide. Electrolytic zinc cells (2 m. long) made of this ware are in successful operation. Special dense highly vitrified ware suitable for sudden temperature changes is used largely in the electrolytic alkali industry. Bodies containing cordierite are more resistant to caustic alkalis and are recommended for equipment subjected alternately to acid and alkali treatment. Bodies containing electrically fused alumina are highly resistant to abrasion. F.G.H.

Small capacities in general and the manufacture of small pots in particular. T. W. GARVE. *Ceram. Age*, **34** [2] 41–43 (1939).—The fundamental requirements of flowerpot manufacture are described from the standpoint of a small plant using approximately five tons of clay per day. F.G.H.

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Form for pressing roofing tile. LUDWIG FRANZ LUDOWICI. Ger. 679,338, July 13, 1939 (July 25, 1934); VI/80*a*. 48.01.—A form for pressing roofing tile, etc., has grooves for taking up excess material. The material is removed from these grooves by channels and is cut away from the product being pressed by the pressure exerted by the interlocking of the opposite section of the form. D.A.B.

Gutter tile. ERNST KÜHL. Ger. 677,432, June 1, 1939 (March 9, 1937); V/37*c*. 1.06.—A design for gutter tile for pantile roofs is given. D.A.B.

Improved tile. GRANDES TUILERIES DE ROUMAZIÈRES. Fr. 849,766, Feb. 3, 1939. D.A.B.

Tile. VIELLARD MIGEON ET CIE. Fr. 848,496, Jan. 5, 1939. D.A.B.

Whiteware

Domestic manufacture of translucent china. ANON. *Ceram. Ind.*, **33** [6] 37–38 (1939).—In October, 1938, when it was apparent that Czechoslovakian imports would soon be cut off, Scammell China Co. of Trenton, N. J., was asked to manufacture a line of fine, translucent chinaware for domestic sale. It was started in January, 1939, and is being made along with hotel ware. The fine china is considerably thinner and weighs about 25% less

than comparable hotel ware. The thinning of walls has required adjustments in body composition, e.g., increase in flint to add to the strength and increase translucency. Much greater care must be exercised in the potting processes, especially in jiggering. The body has a firing shrinkage of nearly 20%, and warpage losses are high, though decreasing. After drying, cups and small bowls are put on a rotating wooden chuck so that the foot may be accurately trimmed to size with a zinc template. All bisque is bedded in flint and fired in saggers, and flatware is fired in inverted position with the top surface resting on humps. Shrinkage rims are used for certain pieces to prevent warpage. Glost ware is fired in round, fully muffled, oil-fired periodic kilns which are of a double-shell type of construction to give a perfectly gastight inner wall. L.M.C.

Lepidolite as a flux in whiteware bodies. C. Major Lampman. Presented at the annual meeting of the New York Ceramic Assn., Alfred, Oct., 1939; abstracted in *Ceram. Ind.*, **33** [6] 40 (1939). L.M.C.

Polishing of scratches on glazes. Felix Singer. *Trans. Brit. Ceram. Soc.*, **38** [9] 513–21 (1939).—Fused and ground feldspar is used to polish hard-paste porcelain in Europe, tin oxide is frequently used for this purpose in the U. S., and quartz is generally used in Great Britain. Quartz frequently contains sericite which may be the cause of the much-feared silicosis. S. points out that agalmatolite, which contains no sericite, may prove satisfactory for polishing. The nature of the grinding and polishing processes is discussed in detail. R.A.H.

Preroasted titanium oxide in insulator bodies. Anon. *Ceram. Ind.*, **33** [6] 48 (1939).—The introduction of finely ground preroasted titanium oxide into ceramic insulators gave the following desired properties in the body: (1) high specific inductive capacity, (2) ease of manufacturing and forming into desired shapes, (3) relatively low drying and firing shrinkages, (4) constant specific inductive capacity under increasing temperatures, (5) low power factor, (6) small phase angle, (7) high puncture strength, (8) high resistance to weathering, and (9) freedom from burning under momentary flashovers. Use of the titanium oxide also eliminated one firing from the process of double firing which was previously necessary to achieve a part of the total shrinkage so that parts could be trimmed to absolute finished size. An alkali titanium silicate, such as potassium or sodium titanium silicate, when finely ground in water, possesses the properties of a suitable electrolyte and an efficient fluxing material when used in amounts up to 3% of the weight of the solids. L.M.C.

PATENTS

Etched spark plug. Richard Stribeck (Robert Bosch G.m.b.H.). U. S. 2,180,779, Nov. 21, 1939 (June 18, 1938).

Floor discharging defecator. W. C. Groeniger (John B. Pierce Foundation). U. S. 2,180,585, Nov. 21, 1939 (Jan. 5, 1937).

Spark plug. W. P. Innes, Jr. U. S. 21,294, Dec. 12, 1939 (Oct. 30, 1939); reissue of 2,097,460, Nov. 2, 1937. A. A. Kasarjian. U. S. 2,180,528, Nov. 21, 1939 (Sept. 9, 1933). H. P. Sparkes. U. S. 2,182,061, Dec. 5, 1939 (Sept. 29, 1938).

Toilet. J. G. Bruzenak. U. S. 2,182,979, Dec. 12, 1939 (Oct. 14, 1938). U. S. 2,182,980, Dec. 12, 1939 (March 30, 1939).

Equipment and Apparatus

Aid to efficient combustion. Anon. *Laboratory*, **10** [3] 52–53 (1938).—The new Dwyer CO_2 indicator is described and illustrated. F.G.H.

Apparatus for determining moisture by the distillation method. A. C. Beckel, A. G. Sharp, and R. T. Milner. *Ind. Eng. Chem., Anal. Ed.*, **11** [8] 425–26 (1939).—Illustrated. F.G.H.

Determination of high viscosities with the Gardner mobilometer. E. L. Baldeschwieler and L. Z. Wilcox. *Ind. Eng. Chem., Anal. Ed.*, **11** [10] 525–26 (1939).—A setup for Gardner mobilometers is described which provides accurate temperature control and easy operation. The conclusions of Cornthwaite and Scofield that the correlation between absolute viscosity and mobility is a straight line were checked for much higher viscosities, at various temperatures, and for different disks. Provided rigid control of time and temperature is obtained and improvements in mechanical construction are made, the mobilometer can be used as a precision instrument for the determination of absolute viscosity. Illustrated. F.G.H.

Filter rates for clay-oil slurries. H. H. Bible, M. A. Witte, and J. W. Donnell. *Ind. Eng. Chem.*, **31** [8] 1007–11 (1939).—Evidence is presented to show that Poiseuille's law does not describe closely enough for engineering calculations the rate of flow through both filter cloth and filter cake for clay-oil slurries. Average cloth resistance varying from 8 to 40% (during a single filter cycle) of the total pressure drop has been found. The law describing the relation of filter rate (R) to pressure drop (P_1) through the filter cloth was $R = KP_1^{0.5}$, showing turbulent flow through the cloth. The empirical equation, $V^{1.33} = K\theta$, was found to describe the flow through both the cake and the cloth for a number of filter presses, both experimental and commercial. Pressures were varied from 15 to 50 lb. per sq. in., and viscosity was varied from 0.0095 to 0.0013 lb. per ft.-sec. Camera-lucida diagrams of the cross-sectional area of the filter cake, showing void space, are included. Illustrated. F.G.H.

Flow pattern and pressure drop in cyclone dust collectors. C. B. Shepherd and C. E. Lapple. *Ind. Eng. Chem.*, **31** [8] 972–84 (1939).—An investigation of a 12-inch glass cyclone showed that the flow within the cyclone consists primarily of an outer downward spiral and an inner upward spiral of higher velocity. The rotational velocity at any point in the cyclone chamber below the exit duct varies inversely as the square root of the radius. The friction loss in the cyclone varies as the square of the inlet velocity, and, for a given velocity, it varies directly as the inlet height and the inlet width and inversely as the square of the exit-duct diameter. The presence of dust in the air stream reduced the cyclone pressure drop as much as 16% at dust loadings of 20 to 30 grains per cu. ft. Straightening vanes inserted in the exit duct and extending below it reduced the pressure drop as much as 50%. Data on the pressure drop with various other internal and external modifications are also given. Illustrated. F.G.H.

Furnace photography. A. A. Markson. *Combustion*, **10** [12] 24–26 (1939).—M. offers practical suggestions on the technique of taking views within a furnace with an ordinary miniature camera having a metallic bellows and with commercially available films. Several still pictures for which infrared film was used are reproduced. Motion pictures and color photography are also discussed. H.E.S.

High-temperature combustion furnace. Anon. *Laboratory*, **9** [1] 6–7 (1937).—The characteristics of a furnace capable of operation at 2400°F are described. Illustrated. F.G.H.

Improved micro combustion furnace. Anon. *Laboratory*, **11** [2] 42–43 (1939).—An electric micro combustion furnace providing temperatures from 200° to 1700°F is described and illustrated. F.G.H.

Influence of bends in inlet ducts on the performance of induced-draft fans. L. S. Marks, J. Lomax, and R. Ashton. *Trans. Amer. Soc. Mech. Engrs.*, **55** [11] 133–43

(1933).—A great loss in the capacity and efficiency of a fan results from the location of elbows or bends close to the inlet boxes. Illustrated. F.G.H.

Influence of bends or obstructions at the fan discharge outlet on the performance of centrifugal fans. L. S. MARKS, J. H. RAUB, AND H. R. PRATT. *Trans. Amer. Soc. Mech. Engrs.*, **56** [10] 767–72 (1934).—Illustrated. F.G.H.

Maintenance of optical pyrometers. MARY BAEYERTZ AND JOHN F. PERKINS. *Metal Progress*, **36** [2] 145–48 (1939).—It is necessary that the pyrometer be in good working condition, both as an assemblage and in all its individual parts. This depends on routine weekly cleaning, inspection, and calibration. The method used in the Carnegie-Illinois Steel Corp. is described in detail. J.J.H.

Microscopy in industrial research and control. E. B. ASHCRAFT. *A.S.T.M. Bull.*, No. 98, pp. 13–17 (May, 1939).—A. discusses the science of microanalytical work, the observation of particles down to 1/13,000,000 in., the possibilities of this field of microchemistry, and the equip ment necessary for such work. The related science of micrurgy (the technique of manipulating small amounts of materials) is described. A test procedure is presented, and the advantages and applications of polarized light are listed. 4 illustrations. F.F.

Modern pyrometry. H. HIRST. *Chem. Eng. & Mining Rev.*, **32** [373] 19 (1939).—H. discusses various types of thermocouples, with special emphasis on their construction, installation, and standardization. B.C.R.

Nondestructive testing in the United States: II, Radiographic methods. H. H. LESTER, R. L. STANFORD, AND N. L. MOCHEL. *A.S.T.M. Bull.*, No. 96, pp. 13–18 (Jan., 1939).—A general review of radiography, with a historical introduction to the commercial applications, is presented. Detailed information is given on the application of radiography in the foundry and in the weld shop. The work of the Industrial Radiographic Committees of the A.S.T.M. is reviewed. 8 illustrations. F.F.

Optical pyrometers. MARY BAEYERTZ. *Metal Progress*, **36** [4] 403–404 (1939).—B. discusses the present optical pyrometers and the progress that may be expected in future instruments. J.J.H.

Precision radiography. GILBERT E. DOAN. *A.S.T.M. Bull.*, No. 97, pp. 27–28 (March, 1939).—D. discusses the high sensitivity required in radiographs for the detection of small shrinkage cracks and porosity in welds and other metallic bodies. A comparison is made between the method used for the detection and a solar eclipse to get the proper definition from the shadow. If the diameter of the radium capsule or cathode spot of an X-ray tube, the diameter of the smallest flaw to detect, the thickness of the metal section, and the diameter of the smallest shadow detectable are known, it is possible by geometry to calculate the minimum distance the source must be placed from the object to get dependable definition. This is of importance only for small flaws. F.F.

Psychrometric chart; application and theory: IV. WILLIAM GOODMAN. *Heating, Piping & Air Conditioning*, **11** [9] 549–51, 567 (1939).—Wet-bulb temperature and two methods of drawing the lines of constant wet-bulb temperature on the psychrometric chart are discussed. 3 figures. For Parts **II, III,** and **V** see *Ceram. Abs.*, **19** [1] 21 (1940). J.L.G.

Radiation pyrometers. P. H. DIKE. *Metal Progress*, **36** [4] 407 (1939).—D. discusses the increased application of radiation pyrometers in the metal industries, both ferrous and nonferrous. He points out that the radiation pyrometers promise the successful measurement of high temperatures in locations and under conditions where the standard thermocouple is not practical. See "Pyrometry—," *Ceram. Abs.*, **17** [1] 30 (1938). J.J.H.

Temperature regulation. S. L. BARRON. *Elec. Rev.*, **125** [3229] 487–89 (1939).—B. discusses the principles and application of mechanical and electrical types of automatic temperature-control apparatus. 5 photographs. J.L.G.

Volume-shape factor of particulate matter; probable errors in the computation. J. M. DALLA VALLE AND F. H. GOLDMAN. *Ind. Eng. Chem., Anal. Ed.*, **11** [10] 545–46 (1939).—The authors present experimental evidence of the variation in shape factor for crushed quartz particles in the range of 10- and 40-mesh Bureau of Standards calibrated screens. F.G.H.

SEPARATE PUBLICATION

Hardness Scales; Table of Approximate Comparison of Hardness Scales. British Standard Specification No. 860—1939. BRITISH STANDARDS INSP., London. Price 2s.—A table shows a comparison of the diamond pyramid scale, Brinell (steel ball) scale, and the direct reading hardness test (Rockwell principle), but it is pointed out that there can be no general theoretical relationship between these scales. A.B.S.

PATENTS

Arrangement for sealing the ends of electrically heated fire-tube heating bodies. KARL BUSSE (Siemens-Schuckertwerke A.-G.). Ger. 677,607, June 1, 1939 (Dec. 30, 1936); VIII*c*/21*h*. 2.02.—The ends of an electrically heated fire-tube heating body are sealed by means of a refractory moisture-tight material (a conductor of electricity only at high temperatures), such as glass, and by means of a ceramic body which serves for closing the jacket tube. The ceramic body is attached by means of vitreous fluxes to the jacket tube and to the electric heating element passing through the tube to render the tube moisture tight. The tube and heating element are separated by a space depending on the voltage. D.A.B.

Crockery and tableware washing machine. H. W. RODDA. Can. 384,079, Sept. 19, 1939 (April 6, 1938). G.M.H.

Dust-collection apparatus. H. W. PFEFFER AND H. O. DANZ (American Blower Corp.). U. S. 2,182,854, Dec. 12, 1939 (July 24, 1937).

Electrostatic separation. F. A. FAHRENWALD, N. F. PARKINSON, AND G. H. BARNES (International Titanium, Ltd.). U. S. 2,180,804, Nov. 21, 1939 (Aug. 24, 1936).

Endless screw press for preparing and feeding ceramic material in the shredded form. GOTTFRIED WELZEL (Gudrun Philipp Welzel). Ger. 678,466, June 22, 1939 (Oct. 1, 1936); VI/80*a*. 26.—One or more cylinders with a number of openings are arranged directly over the opening of the housing of the press; these cylinders are charged by means of a feeder consisting of a powered worm screw. D.A.B.

Heat-resisting and refractory element. SOC. ANON. DES ÉTABLISSEMENTS A. VALUY. Fr. 848,298, June 30, 1938. D.A.B.

Induction furnace. E. G. SCHLUP (American Rolling Mill Co.). U. S. 2,181,921, Dec. 5, 1939 (Jan. 5, 1938).

Machine for cutting brick, tile, etc. J. B. FAGIOLI. Fr. 836,886, April 20, 1938. D.A.B.

Machine for cutting tile, etc. C. A. MARTIN. U. S. 2,180,743, Nov. 21, 1939 (March 21, 1939).

Machine for extruding clay, etc. TYNE METAL CO., LTD., AND G. ROBSON. Brit. 514,444, Nov. 22, 1939 (May 5, 1938).

Machine for manufacturing clay products. C. E. DOLL AND C. F. COPELAND. U. S. 2,180,895, Nov. 21, 1939 (March 22, 1937).

Matrix-making method. A. W. KLOMP (Carborundum Co.). Can. 384,113, Sept. 19, 1939 (May 28, 1937; in U. S. June 1, 1936). G.M.H.

Press for producing pyrometric cones. H. E. COVAN AND G. A. BOLE (Standard Pyrometric Cone Co.). U. S. 2,181,619, Nov. 28, 1939 (Dec. 16, 1935).

Kilns, Furnaces, Fuels, and Combustion

Atomization of oil by small pressure atomizing nozzles. E. B. GLENDENNING, A. R. BLACK, L. H. VENTRES, AND W. A. SULLIVAN. *Trans. Amer. Soc. Mech. Engrs.*, **61** [5] 373–81 (1939).—Illustrated. F.G.H.

Burning oil-refinery fuels. A. L. WILSON. *Trans. Amer. Soc. Mech. Engrs.*, **61** [8] 699–704 (1939); *Combustion*, **10** [9] 27–29 (1939).—Burner design and the use of steam for atomization are considered, and attention is called to the combination burners that have been developed to burn simultaneously five different fuels in liquid, gaseous, and solid form. Illustrated. F.G.H. + H.E.S.

By-product fuels in the steel industry. E. G. FOX AND W. B. CLEMMITT. *Trans. Amer. Soc. Mech. Engrs.*, **61** [8] 665–72 (1939).—It is recommended that by-product fuels be utilized in processes where the greatest economic value will result. The method of arriving at the potential values of these gases in relation to those of tar, fuel oil, and coal is fully expounded, several examples of cost analyses being cited to illustrate the procedure. Illustrated. F.G.H.

Characteristics of atmospheric-type burners when used with natural gas. E. D. HOWE AND H. G. JOHNSON. *Trans. Amer. Soc. Mech. Engrs.*, **61** [8] 673–77 (1939).—Natural gas can be burned at the rate of approximately 30 cu. ft. per hr. per sq. in. of port area. The authors summarize the matter of hydraulic design of inspirators in the form of an equation, the validity of which is demonstrated by experiment. This equation suffices to determine the mixture ratio when the gas rate and density are known. Illustrated. F.G.H.

Distribution of energy in the pulverized-coal furnace. W. J. WOHLENBERG AND D. E. WISE. *Trans. Amer. Soc. Mech. Engrs.*, **60** [7] 531–48 (1938).—In this analysis the coal particle while burning is distinguished from the resulting ash particle, and the concept of radiant-mean positions of burning particles and ash particles is introduced. This makes it possible to differentiate between the radiant-mean temperatures of burning particles, ash particles, gases, refractory walls, and cold walls. The direct transfer of energy between each class of particles and the gases is also introduced into the equations of condition. This process is of primary importance in the energy distribution; in fact, it may be thought of as a powerful binding property which holds the energy distribution in the configuration which it assumes. It provides, among other things, for a small difference between the values of the radiant-mean temperatures of ash particles and gases; hence, for any reasonable length of gas travel in the cavity, the ash-particle temperature is substantially that of the gases except for regions close to a cold surface. In view of the importance of ash fusion in the actual operation of furnaces, this disclosure is of considerable practical significance. With respect to the radiation absorption at walls of the cavity, it is found that burning particles are the least important of the three radiators, burning particles, ash particles, and gases. The burning particles are primarily a source for releasing energy, and most of this is transferred directly to the gases by thermal conduction. The gases, therefore, serve momentarily as a great sump or reservoir into which most of the released energy is dumped. A part of this large fraction of the total released energy is subsequently redistributed by radiation and thermal conduction. The foregoing information results from a solution of the equilibrium conditions for a steady state in a given cavity. On the basis of information furnished in this way it is possible to approximate the distribution of energy absorption as heat over the cold walls of the cavity. The results for a given case are presented. In a qualitative sense, these results contain implications of rather general significance. On the basis of information furnished in the equilibrium solution, it is possible to approximate the gradient along the flame axis of a single radiant mean temperature as representing the temperature condition of the contents of the cavity. Such a gradient, however, has little practical significance except in its lower reaches. Nevertheless, a method of arriving at it is included, together with a more detailed discussion. Illustrated. F.G.H.

Effect of oxidation of anthracite on its heating value. G. S. SCOTT, G. W. JONES, AND H. M. COOPER. *Ind. Eng. Chem.*, **31** [8] 1025–27 (1939).—The relation of heating value, volatile matter, and ash content for 1008 samples of anthracite is presented graphically. Illustrated. See "Oxidation—," *Ceram. Abs.*, **18** [1] 32 (1939). F.G.H.

Effect of preparation on ash fusibility as revealed by a study of selected Illinois coals. L. C. MCCABE AND O. W. REES. *Trans. Amer. Soc. Mech. Engrs.*, **61** [8] 693–98 (1939).—Illustrated. F.G.H.

Electric carbonization of coal. H. STEVENS. *Trans. Electrochem. Soc.*, **75**, 167–83 (1939).—S. shows that construction and maintenance costs are lower for the electric process. The coke produced has uniform burning qualities, and the oil is of superior quality. The process is adaptable to off-peak electric power. Illustrated. F.G.H.

Hydrogenation tests on Canadian coals ranging from medium-volatile bituminous to lignite. T. E. WARREN, K. W. BOWLES, AND R. E. GILMORE. *Ind. Eng. Chem.*, **31** [8] 1021–25 (1939).—Hydrogenation tests on nine coals representative of various groups in the A.S.T.M. classification between medium-volatile bituminous coal and lignite are described. Illustrated. F.G.H.

Judging coal values. G. B. GOULD. *Combustion*, **10** [10] 29–34 (1939).—A procedure for coal selection is as follows: (1) fuel-engineering analysis of the plant, (2) qualitative selection of coals suited to the requirements of the plant, (3) preliminary value appraisal to eliminate all but the best values, and (4) final quantitative valuation. The great diversity in coal-buying problems is stressed, and the importance of employing a heat-balance analysis to guard against misinterpretation of comparative trials is pointed out. H.E.S.

Permanganate oxidation index as a criterion of coal rank. H. L. OLIN, P. L. CONRAD, MARION KROUSE, AND R. E. WHITSON. *Ind. Eng. Chem., Anal. Ed.*, **11** [9] 489–91 (1939).—Illustrated. F.G.H.

Phase equilibria in hydrocarbon systems: XXVI, Methane–ethane system in the gaseous region. B. H. SAGE AND W. N. LACEY. *Ind. Eng. Chem.*, **31** [12] 1497–1509 (1939).—The fugacity, partial volume, and partial enthalpy of methane and ethane are presented in graphical and tabular form. For Part **XXIV** see *Ceram. Abs.*, **18** [9] 251 (1939). F.G.H.

Problems related to the preparation of Illinois coals. L. C. MCCABE. *Trans. Amer. Soc. Mech. Engrs.*, **61** [1] 1–4 (1939).—Illustrated. F.G.H.

Pulverized coal-tar pitch as a fuel. E. W. CLARKE. *Trans. Amer. Soc. Mech. Engrs.*, **61** [7] 577–79 (1939).—The methods of firing fuel pitch are described, and specific examples of the results obtained are cited. Illustrated. F.G.H.

Relation of ash composition to fusing temperature in anthracite. OSCAR W. PALMENBERG. *Ind. Eng. Chem.*, **31** [8] 1058–59 (1939). F.G.H.

Relative grindability of coal. HAROLD J. SLOMAN AND ARTHUR C. BARNHART. *Trans. Amer. Soc. Mech. Engrs.*, **56** [10] 773–80 (1934).—A simplified roll test, designated as the C.I.T. roll test, is based on the principle of increase of new surface measured in accordance with Rittinger's theory of crushing. Twenty-nine representative bituminous-coal samples were tested, and their relative grindabilities were determined by this method. Particle-size determination by the sedimentation-velocity method is discussed. The particle size of −300-mesh coal was studied experimentally, and a more rational value for this size is proposed. Illustrated. F.G.H.

Slag and deslagging of steam-generating equipment. ALEX D. BAILEY. *Trans. Amer. Soc. Mech. Engrs.*, **60** [3] 209–11 (1938).—Reduction of the ash content of the coal by washing or any other means is, of course, ad-

vantageous, but the chemical treatment of coal to eliminate or reduce slagging troubles has been generally unsuccessful. F.G.H.

Use of oil for the treatment of coal. RALPH A. SHERMAN AND J. M. PILCHER. *Trans. Amer. Soc. Mech. Engrs.*, **60** [2] 97–110 (1938).—Illustrated. F.G.H.

Vapor-liquid equilibrium in the system propane–isobutylene. H. W. SCHEELINE AND E. R. GILLILAND. *Ind. Eng. Chem.*, **31** [8] 1050–57 (1939).—A comparison is made between data obtained experimentally and those calculated from the Lewis fugacity equation; a great many differences are found, particularly in the critical region. Illustrated. F.G.H.

SEPARATE PUBLICATIONS

Carbonizing Properties and Petrographic Composition of Sewell Bed Coal from Wyoming Mine, Wyoming County, W. Va., and the Effect of Blending This Coal with Alabama Bed Coal. A. C. FIELDNER, J. D. DAVIS, W. A. SELVIG, R. E. BREWER, C. R. HOLMES, D. A. REYNOLDS, AND G. C. SPRUNK. *U. S. Bur. Mines Tech. Paper*, No. 601, 45 pp. Supt. of Documents, Govt. Printing Office, Washington, D. C. Price 10¢. R.A.H.

Reduction of Fly-Ash Emission from Chimneys. J. F. BARKLEY. *U. S. Bur. Mines Repts. Investigations*, No. 3472, 10 pp. Free.—B. discusses the composition of fly ash, amount and sizing of fly-ash emissions, fly-ash reduction, methods of separating fly ash from products of combustion, and choice of fly-ash equipment. R.A.H.

PATENTS

Electric kiln for metallo-ceramic applications. A. KRATKY. Fr. 835,865, March 29, 1938. D.A.B.

Forced circulation fuel-fired furnace. A. H. VAUGHAN (Electric Furnace Co.). U. S. 2,181,928, Dec. 5, 1939 (Aug. 13, 1937).

Furnace electrode assembly. MATHIAS OVROM SEM (Det norske Aktieselskab for Elektrokemisk Industri). Can. 384,050, Sept. 12, 1939 (May 3, 1935). G.M.H.

Tunnel kiln. ELECTRO-SOUDURE. Fr. 834,332, July 20, 1937. D.A.B.

Geology

Applications of electrophoresis and electroosmosis in the ceramic industries. CARL E. CURTIS. *Trans. Electrochem. Soc.*, **73**, 503–10 (1938).—The application of electrophoresis to the dewatering of clay suspensions and of electroosmosis to steel-die lubrication in the stiff-mud process is briefly described. Illustrated. F.G.H.

Characteristics of Illinois pottery clay. C. G. HARMAN. *Jour. Amer. Ceram. Soc.*, **23** [1] 26–29 (1940).

Chromite. W. F. BRAZEAU. *Mineral Ind.*, **47**, 65–78 (1938).—The production and the exportation of chrome ore during 1938 by the chromite-producing countries are given. Of the 100 or more known deposits in Turkey, seven are important ones whose Cr_2O_3 assays as follows: Fethiye, 40 to 50; Marmaris and Mersine, 40 to 47; Kutahya, Eskisehir, and Guleman, 44 to 52; and Denizli and Tefenni, 50 to 54%. B.C.R.

Colloidal clays: I. E. A. HAUSER AND D. S. LE BEAU. *Jour. Phys. Chem.*, **42**, 1031 (1938).—The increase in specific gravity and in absolute viscosity of monodisperse montmorillonite fractions with increasing concentration and decreasing particle size is noted, and the specific gravity effect is explained by the presence of strongly adsorbed water on the particles. The yield point and viscosity decrease with increasing temperature. Gelation causes a sudden rise in optical density. Preliminary studies in stream double refraction indicate it to be a function of particle size and concentration. See "Gelation—," *Ceram. Abs.*, **19** [1] 26 (1940). R.A.G.

Diffraction of X rays by crystals at elevated temperatures. G. D. PRESTON. *Proc. Roy. Soc.* [London], **A172**, 116–27 (1939).—Certain diffuse spots on Laue photographs which increase in intensity as the temperature is raised to 500°C are attributed to thermal vibrations of the lattice. Single crystals of aluminum, rock salt, and periclase were studied. A.P.

Froth flotation economically recovers valuable material from talc waste. W. E. TRAUFFER. *Pit & Quarry*, **32** [4] 28–30 (1939).—Economical recovery of 95% pure talc from dry-plant waste (talc 55, magnesite 35, and other impurities 10%) by froth flotation is now possible. Plant equipment and flowsheet are described. A.G.S.

Guide to the geology of the Golden area, Colorado. F. M. VAN TUYL, J. HARLAN JOHNSON, W. A. WALDSCHMIDT, JAMES BOYD, AND BEN H. PARKER. *Quart. Colo. School Mines*, **33** [3] 1–32 (1938).—Clay, sand, and feldspar deposits are described in detail. Illustrated. F.G.H.

Hypotheses of quartz orientation in tectonites. H. W. FAIRBAIRN. *Bull. Geol. Soc. Amer.*, **50** [10] 1475–92 (1939).—Three hypotheses of quartz orientation in tectonites, based on twinning, translation, and fracture, are considered. Emphasis is placed on the fracture hypothesis, following the ideas of Griggs and Bell ("Experiments—," *Ceram. Abs.*, **18** [6] 164 (1939)). An attempt is made to apply it to tectonites showing *ac*-girdles and oblique girdles, using published diagrams and also a series of new ones. The correlation is instructive but only partially successful. F. concludes that there is no direct evidence supporting the twinning or the translation hypothesis but that the fracture hypothesis is supported by this study. A.C.B.

Mineral composition of Finnish clays. ANTTI SALMINEN. *Suomen Kemistilehti*, **12A** [1] 2–7 (Jan., 1939); abstracted in *Chem. Zentr.*, **1939, II**, 2033.—Three Finnish clays were examined chemically and roentgenographically. Kaolin was negligible. Feldspar was found in considerable amounts. The chemical analysis showed large amounts of mica. The relatively high specific gravity (2.729) of the clays indicates the presence of primary minerals, as the density of the clay minerals, with the exception of mica, is very low. M.V.C.

Physical chemistry of clay as related to paper filling. C. G. ALBERT. *Trans. Electrochem. Soc.*, **73**, 173–82 (1938).—Illustrated. See *Ceram. Abs.*, **18** [4] 113 (1939). F.G.H.

Physicochemical control of the properties of clays. JOHN D. SULLIVAN. *Trans. Electrochem. Soc.*, **75**, 71–98 (1939).—Plasticity, workability, and other properties of clays are largely governed by the colloidal nature of the clay, which in turn is dependent on the water film surrounding the particle. The water film is dependent on the nature of the charges in the ion atmosphere surrounding the particle. Replacement of an exchangeable base with another cation may change the character of the water film and, consequently, certain properties of the clay. Experimental data are given on the effect of exchangeable bases on the properties of a plastic fire clay. Illustrated. F.G.H.

Quartz crystals. ANON. *Chem. Eng. & Mining Rev.*, **32** [373] 14 (1939).—Exports of Brazilian rock crystal during 1938 increased from a previous 14-year average of 300,000 kg. to over 746,000 kg. Quartz crystals are used chiefly for piezoelectrical and optical purposes in the U. S. and for fused ware and radio equipment in England; these countries were the chief importers. Numerous other uses of quartz crystals are given. B.C.R.

Reciprocal action of feldspar, pyroxene, and sulfide melts. D. P. GRIGOR'EV. *Zapiski Vserossiiskogo Mineral. Obshchestva*, **67** [1] 7–17 (1938); abstracted in *Chem. Zentr.*, **1939, II**, 1654.—Mixtures of 58 diopside and 42% anorthite or 62 diopside and 38% plagioclase were melted with FeS to 1300°. The melts separated into a lower sulfide layer where 8 to 10% silicate is dissolved and an upper silicate layer in which very little sulfide is dissolved. M.V.C.

Role of adsorption in the coagulation of sols by electrolytes. HARRY B. WEISER, W. O. MILLIGAN, AND W. J. COPPOC. *Jour. Phys. Chem.*, **42**, 427 (1938).—In the coagulation of sols of the hydrous oxides of iron, aluminum, and chromium and of arsenic trisulfide, sulfur, and copper ferrocyanide, practically complete coagulation by electrolytes takes place at or below the point of maximum adsorption of the precipitation ion. The coagulation results from the lowering of the electrokinetic potential, which is caused by contraction of the double layer. Anomalous results with silver iodide sols are explained. R.A.G.

SEPARATE PUBLICATIONS

Annual Report on the Mineral Production of Canada During 1937. DOMINION BUREAU OF STATISTICS, Canada, 1939. 333 pp. Price 50¢. G.M.H.

Mining Laws of Canada. ARTHUR BUISSON. *Can., Dept. Mines & Resources, Bur. Mines Pub.*, No. 795, 110 pp. (1939). Price 25¢.—B. has compiled dominion and provincial government laws and regulations pertaining to the mining of minerals. G.M.H.

PATENTS

Refining clay. S. C. LYONS (Bird Machine Co.). U. S. 2,180,742, Nov. 21, 1939 (May 12, 1937).—In a process of refining aqueous clay suspension containing ferric oxide as a coloring impurity which involves the reduction of the ferric oxide in the suspension to a substantially colorless, water-soluble ferrous salt, steps comprise treating the suspension containing dissolved therein the colorless ferrous salt with alkali-metal polymetaphosphate in amount sufficient to inhibit reversion of such salt to ferric oxide and separating the clay from suspension.

Removing iron from quartz sand. WILHELM BOCK. Ger. 678,380, June 22, 1939 (March 27, 1937); IV*b*/12*i*. 38.—Quartz sand which has been previously washed is heated in a chamber kiln at a temperature of 80° to 120°C with a proportionately small quantity of concentrated (or almost concentrated) hydrochloric acid. The acid vapors are continuously removed or extracted from the kiln, and, upon condensation of the acid vapors, the acid is used over again in the same cycle. The charging of the kiln, the removal of the charge from the kiln, the operation of washing the sand with water, and the adding of the acid to the sand within the kiln are brought about with continuous occlusion to the outside air. D.A.B.

Chemistry and Physics

Boron determination in soils and plants using the quinalizarin reaction. K. C. BERGER AND E. TRUOG. *Ind. Eng. Chem., Anal. Ed.*, **11** [10] 540–45 (1939).—By means of the quinalizarin color reaction it is possible with proper control of the acidity to detect 0.0001 mg. of boron. F.G.H.

Carbon and hydrogen determinations; effect of pressures on lessening combustion and sweeping times. S. STEVEN BRODIE. *Ind. Eng. Chem., Anal. Ed.*, **11** [9] 517–18 (1939).—The substitution of silver supported on asbestos for silver wool increases the efficiency of the combustion tube in the removal of halogen. Combustions under increased pressure ensure completeness of oxidation and removal of halogen, sulfur, nitrogen, etc. Absorptions under pressure ensure complete removal of water and carbon dioxide. See "Determination—," *Ceram. Abs.*, **18** [2] 60 (1939). F.G.H.

Citrate solubility of dolomite of varying particle size. C. W. WHITTAKER, L. F. RADER, JR., AND K. V. ZAHN. *Jour. Assn. Official Agr. Chemists*, **22** [1] 180–89 (1939). F.G.H.

Colorimetric method for determining barium. H. A. FREDIANI AND B. J. BABLER. *Ind. Eng. Chem., Anal. Ed.*, **11** [9] 487–89 (1939).—Barium may be determined rapidly by precipitating it as the chromate, dissolving it in hydrochloric or nitric acid, and comparing the resultant solution with a colorimetric standard. In analyzing a solid sample containing barium, a sufficient weight of sample should be taken to yield a final solution (for comparison) containing 0.2 to 1 mg. of barium per milliliter of solution. The use of green and blue filters may extend these limits. For the lower concentrations, heights of 30 mm. in the colorimeter yield most consistent results, while for the higher concentrations heights of 15 and 20 mm. are recommended. The presence of sodium, potassium, calcium, and magnesium ions in equivalent amounts does not affect the determination of barium. The concentration of acid used to effect solution is not critical. The presence of strontium ion leads to erroneously high results. Its effect may be obviated, as in the gravimetric method, by careful double precipitation. Illustrated. F.G.H.

Crystallization equilibrium in nepheline-albite-silica mixtures with fayalite. NORMAN L. BOWEN AND J. F. SCHAIRER. *Jour. Geol.*, **46** [3, Part II] 397–411 (1938).—The authors present the results of a thermal study of the system $NaAlSiO_4$–FeO–SiO_2 and discuss their application to petrology. The crystalline phases formed in the various compositions are cristobalite, tridymite, albite, fayalite, nepheline, carnegieite, hercynite, and wüstite. There are two ternary eutectics; one is between tridymite, albite, and fayalite (temperature 980° ± 10°C), which may be regarded as a simplified fayalite rhyolite, and the other is between nepheline, albite, and fayalite (temperature 990° ± 10°C), which may be regarded as a simplified fayalite phonolite. These findings and others are discussed in connection with the origin of natural phonolites, trachytes, and rhyolites carrying fayalite. See "System —," *Ceram. Abs.*, **15** [10] 315 (1936). A.C.B.

Determination of fluorine by the peroxidized titanium method. DAN DAHLE. *Jour. Assn. Official Agr. Chemists*, **20**, 505–16 (1937).—A new procedure for making fluorine determinations by the peroxidized titanium method is presented. A neutral wedge photometer is used for the colorimetric comparison, and the effectiveness of aluminum salts in inhibiting the bleaching ordinarily caused by fluorine in a solution of peroxidized titanium is utilized. Experimental data pertaining to the development of the procedure and typical results and applications are given. F.G.H.

Determination of fluorine in phosphatic materials, with special reference to the Willard and Winter method. D. S. REYNOLDS. *Jour. Assn. Official Agr. Chemists*, **17**, 323–29 (1934).—The Willard and Winter method is more accurate than either the volatilization method or the fusion-acid extraction method for determining fluorine in mineral phosphates and calcined phosphates; it also gives good results on phosphate-furnace slags. **Further studies on the Willard and Winter method.** *Ibid.*, **18**, 108–13 (1935).—When the Willard and Winter method is used for the determination of fluorine in slag, phosphate rock, and calcined phosphate, a coating of precipitated silica, which tenaciously retains fluorine, gradually accumulates on the walls of the distillation flask. Serious errors may arise when the flask is used successively in the analysis of samples containing widely different quantities of fluorine. The coating of silica is easily removed by boiling with strong sodium hydroxide solution. See "Occurrence—," *Ceram. Abs.*, **12** [1] 32 (1933). F.G.H.

Determination of fluorine in the presence of a large excess of aluminum ions. DAN DAHLE AND H. J. WICHMANN. *Jour. Assn. Official Agr. Chemists*, **19**, 320–27 (1936).—A study of the separation of small quantities of fluorine from large amounts of aluminum is presented. F.G.H.

Determination of monocalcium phosphate by means of urea. COLIN W. WHITTAKER, FRANK O. LUNDSTROM, AND W. L. HILL. *Jour. Assn. Official Agr. Chemists*, **18**, 122–27 (1935).—Accurate results were obtained on pure monocalcium phosphate and on mixtures of monocalcium phosphate with various phosphate materials. The method

was also used satisfactorily to determine the P_2O_5 present as monocalcium phosphate in ordinary and double superphosphates. F.G.H.

Determination of quartz (free silica) in refractory clays. L. J. TROSTEL AND D. J. WYNNE. *Jour. Amer. Ceram. Soc.*, **23** [1] 18–22 (1940).

Determination of selenium. A. L. CURL AND R. A. OSBORN. *Jour. Assn. Official Agr. Chemists*, **21**, 228–35 (1938).—A comparative study made of a number of digestion procedures showed that several, although not all, are equally satisfactory. A simplified HNO_3-H_2SO_4-HgO digestion procedure was developed. The use of the starch indicator in the volumetric determination of selenium by reduction of selenious acid with thiosulfate was studied and found to be quite satisfactory for amounts of selenium above 5 γ. The digestion procedure developed and the volumetric determination with the starch indicator are described. F.G.H.

Direct determination of alumina in certain silicates. E. W. KOENIG. *Ind. Eng. Chem., Anal. Ed.*, **11** [10] 532–35 (1939).—The determination of alumina as the quinolate in the presence of silica and iron is feasible. Details of a method which has definite advantages over methods ordinarily employed for this purpose are described. It is economical because no platinum or extremely high temperatures are required and the reagent cost is low. F.G.H.

Dithizone methods for the determination of lead. P. A. CLIFFORD AND H. J. WICHMANN. *Jour. Assn. Official Agr. Chemists*, **19**, 130–56 (1936).—Some physical properties of dithizone are presented, and the mechanism of the lead dithizone reaction is discussed. Dithizone methods are classified, and certain inherent errors are indicated. A photometric method of measuring the color, which increases the sensitivity and accuracy of dithizone methods for lead, is presented. Illustrated. F.G.H.

Effect of particle size on the solubility of magnesium in dolomite and magnesic limestone in 4% citric acid solution adjusted to pH 4.0 with ammonium hydroxide. J. W. KUZMESKI. *Jour. Assn. Official Agr. Chemists*, **22** [1] 147–50 (1939). F.G.H.

Evaluation of yield value with the sphere viscometer. J. C. WILLIAMS AND E. I. FULMER. *Jour. Applied Physics*, **9**, 760–64 (1938).—The capillary tube, rotating cylinder, and moving sphere methods for determining yield values are critically reviewed. A method is proposed for determining yield value by means of the sphere viscometer. The velocity of fall, V, of spheres of identical radius but differing densities is determined in cylinders of identical radii. In the plot of V against $(d_2 - d_1)$ the graph is extrapolated to an intercept, Δ_0, at zero velocity. Substitution in the equation $f = (^2/_9)\, g\, r^2\, \Delta_0\, f_w/(R-r)$ transforms Δ_0 into yield value (g = acceleration due to gravity, r = radius of sphere, R = radius of cylinder, f_w = wall factor = $1 - 2.104\,(r/R) + 2.09\,(r/R)^3 - 0.95\,(r/R)^6$). A.P.

Explanation of pH and pOH. P. B. PLACE. *Combustion*, **10** [9] 33–36 (1939).—With the increasing application of pH to problems of feed-water treatment, corrosion, and high-pressure operation, a widespread acceptance of this symbol has developed without, in many cases, a clear conception of what it means. P. attempts to explain what pH means, how the pH scale is derived, and the relation between pH and acidity and alkalinity. H.E.S.

Hydrogen peroxide in the colorimetric determination of iron by thiocyanate. CHARLES A. PETERS, MAJEL M. MACMASTERS, AND CHESTER L. FRENCH. *Ind. Eng. Chem., Anal. Ed.*, **11** [9] 502–503 (1939).—Hydrogen peroxide is a more satisfactory oxidant for iron than permanganate in the thiocyanate determination of iron. The red color can be made stable for several minutes, depending on the amount of peroxide used, and the faded color may be restored if necessary by the addition of more peroxide. Too much peroxide may cause a yellowish interfering color due to oxidation products of thiocyanate. Illustrated. F.G.H.

Ignition of silicic acid. KNUT A. KRIEGER AND HIRAM S. LUKENS. *Ind. Eng. Chem., Anal. Ed.*, **8** [2] 118 (1936).—The conditions under which a very small residue of silicon carbide may be obtained in the ignition of silicic acid are described. F.G.H.

Mobility studies with colloidal silicic acid. FRED HAZEL. *Jour. Phys. Chem.*, **42**, 409 (1938).—An electrokinetic study of colloidal silicic acid was made with the ultramicroscope. The effect of electrolytes, pH value, and colloids of opposite sign on the mobility was investigated. R.A.G.

Modified technique for the determination of citrate-insoluble P_2O_5. W. H. MACINTIRE AND L. J. HARDIN. *Jour. Assn. Official Agr. Chemists*, **18**, 297–301 (1935).—The determination of citrate-insoluble P_2O_5 in five types of phosphate rock is described. F.G.H.

Multiple-unit distilling apparatus for determining fluorine by the Willard and Winter method. D. S. REYNOLDS, J. B. KERSHAW, AND K. D. JACOB. *Jour. Assn. Official Agr. Chemists*, **19**, 156–62 (1936).—An electrically heated multiple-unit distilling apparatus for the determination of fluorine by the Willard and Winter method is described. With this apparatus, six distillations can be made simultaneously, and 24 determinations can be completed in 8 hr. The performance of the apparatus on typical samples of phosphatic materials is indicated. Illustrated. F.G.H.

Photoelectric colorimetry; an optical study of permanganate ion and of the chromium–diphenylcarbazide system. GEORGE P. ROWLAND, JR. *Ind. Eng. Chem., Anal. Ed.*, **11** [8] 442–45 (1939).—The colorimetric determination of manganese by the periodate method and the determination of chromium by diphenylcarbazide were studied with the object of adapting them to photoelectric colorimetry. An optical method for the separation of interfering ions is discussed in connection with the manganese method. Illustrated. F.G.H.

Preparation of immersion liquids for the range n_D = 1.411 to 1.785. E. P. KAISER AND WILLIAM PARRISH. *Ind. Eng. Chem., Anal. Ed.*, **11** [10] 560–62 (1939).—Illustrated. F.G.H.

Qualitative analysis by spot tests. GORDON H. STILLSON. *A.S.T.M. Bull.*, No. 98, pp. 9–13 (May, 1939).—S. presents a complete discussion of the spot method of qualitative analysis. The spot test consists primarily in placing a drop of unknown material or solution on a piece of filter paper which has been impregnated with a certain reagent. Conclusions are drawn from the color produced. Its advantages are the minute amounts of material needed and the economy in space and time. The limit of identification is given in gammas (0.001 mg.) per 0.05 ml. drop. Equipment for a spot-test laboratory is given in detail, and several test procedures are presented. The analytical method is described as the qualitative analysis of the future. 3 illustrations. F.F.

Quantitative study of fluorine distillation. DAN DAHLE AND H. J. WICHMANN. *Jour. Assn. Official Agr. Chemists*, **19**, 313–20 (1936).—A study of the various factors influencing the recovery of fluorine by the Willard and Winter distillation process is presented. Illustrated. F.G.H.

Rapid estimation of lime in the presence of magnesium salts. A. E. WILLIAMS. *Chem. Eng. & Mining Rev.*, **31** [372] 504 (1939).—The double precipitation of calcium as oxalate to eliminate the magnesium salt may be avoided by the addition of a few drops of glycerine prior to the addition of ammonium oxalate and after the removal of the R_2O_3 group. B.C.R.

Rapid operating device for Orsat apparatus. FRED COOK. *Ind. Eng. Chem., Anal. Ed.*, **11** [10] 551–52 (1939).—Illustrated. F.G.H.

Silica jellies: I. HAROLD W. BATCHELOR. *Jour. Phys. Chem.*, **42**, 575 (1938).—Three-dimensional figures are given showing the effects of concentration, initial pH value, and temperature on the gelation times and on the shifts in pH values of silica sols and jellies. The data permit reconciliation of conflicting statements in the literature. R.A.G.

Ultrasonic waves in colloid chemistry. KARL SOLLNER. *Jour. Phys. Chem.*, **42**, 1071 (1938).—S. discusses the various kinds of disintegration brought about by ultrasonics, e.g., the formation of fogs and emulsions and their action in bringing about coagulation. R.A.G.

Use of peroxides of calcium and magnesium in determining the fluorine content of soils, siliceous materials, and organics. W. H. MACINTIRE AND J. W. HAMMOND. *Jour. Assn. Official Agr. Chemists*, **22** [2] 231–36 (1939). F.G.H.

SEPARATE PUBLICATION

British Standard Definitions of Heat Insulating Terms and Methods of Determining Thermal Conductivity and Solar Reflectivity. British Standard Specification No. 874—1939. BRITISH STANDARDS INST., London. Price 2s.—The following definitions are given: (1) Thermal transmission is the quantity of heat flowing per unit time under the conditions prevailing at that time. (2) Thermal conductivity (k) is measured by the quantity of heat which passes per unit time through unit area of a slab of indefinite extent and of unit thickness, when a unit difference of temperature is established between its faces. (3) Thermal resistivity is the reciprocal of the thermal conductivity. (4) Thermal diffusivity (a) is the thermal conductivity divided by the heat capacity per unit volume. (5) Thermal conductance (C) is the thermal transmission per unit area divided by the temperature difference between the hot and cold faces. (6) Thermal resistance (R) is the reciprocal of the conductance. (7) Thermal transmittance (U) is the thermal transmission through unit area divided by the temperature difference between the air or other fluid on either side. (8) Surface coefficient is the thermal transmission per unit area divided by the temperature difference between the surface and the neighboring air. (9) Surface resistance is the reciprocal of the surface coefficient. (10) Total thermal resistance is the sum of the surface resistances and the thermal resistance of the structure. (11) Shape factor (S) is defined by the equation $q = RS\ (ts_1 - ts_2)$. (12) Reflectivity (r) of a surface for radiant heat is the ratio of the amount of heat reflected to that which is incident to the surface. (13) Emissivity (E) of a surface for radiation is the ratio of the thermal radiation from unit area of the surface to the radiation from a unit area of a "black" surface at the same temperature. (14) Radiation constant (σE) for bodies which follow the fourth-power law of the absolute temperature is defined by $q_r = \sigma E(AT^4)$, where σ (Stefan's constant) is the radiation constant for a black body, of which $E = 1$. (15) Radiation coefficient (f_r) is the net quantity of heat radiated per unit time from a unit area of a surface divided by the temperature difference between the radiating surface and the surroundings. (16) Convection coefficient (f_c) is the quantity of heat carried by convective currents per unit time from unit area of surface divided by the temperature difference between the surface and the surrounding air. For the measurement of thermal conductivity and solar reflectivity three methods are described. The chief systems of units in common use are described briefly. A.B.S.

PATENTS

Improving glass, glazes, and enamels. ADOLF DIETZEL (Deutsche Tafelglas A.-G.). Ger. 678,340, June 22, 1939 (June 29, 1938); VI/32*b*. 6.50. Addition to Ger. 644,097 ("Treatment—," *Ceram. Abs.*, **16** [10] 314 (1937)).—Glass, glazes, and enamels are improved in respect to stability in the presence of chemicals by embodying or incorporating water vapor in the molten mass according to Ger. 644,097. The melts are worked or cooled off in a vapor-free atmosphere or one corresponding in water content to that of a natural atmosphere. D.A.B.

Making titanium dioxide. B. W. ALLAN AND L'R. G. BOUSQUET (American Zirconium Corp.). U. S. 2,182,420, Dec. 5, 1939 (Feb. 11, 1935).—A method of making titanium dioxide comprises digesting ilmenite with sulfuric acid, treating the reaction mass to obtain a clarified solution containing more than 100 g. per liter of TiO_2, having a factor of acidity above 70%, and containing all the sulfate derived from the ilmenite, adjusting the factor of acidity to 20% to 70% by adding a substantial amount of a basic compound which forms a soluble sulfate, hydrolyzing the so-prepared hydrolysis solution, and washing and calcining the precipitate.

Preparation of titanium concentrates. J. E. BOOGE (E. I. du Pont de Nemours & Co.). U. S. 2,183,365, Dec. 12, 1939 (April 7, 1938).—A process for producing substantially iron-free titanium dioxide concentrates comprises heating a titaniferous ore in the presence of a gaseous oxidizing medium to a temperature within the range of substantially 500° to 1000°C and then subjecting the resultant oxidized ore to the action of gaseous hydrogen chloride maintained at a temperature ranging from substantially 600° to 800°C.

Producing a colloidal solution of silicic acid. I. G. FARBENIND. A.-G. Ger. 679,418, July 13, 1939 (Oct. 18, 1935); IV*b*/12*i*. 38.03.—Silicon halides, such as silicon tetrachloride or silicon tetrabromide, are treated with alkylene oxides, e.g., ethylene oxide or propylene oxide, in the presence of water. The organic materials are separated from the resulting reaction mixture. D.A.B.

Silicic acid gel production. E. S. RIDLER (Canadian Industries, Ltd.). Can. 384,487, Oct. 3, 1939 (Dec. 1, 1934). G.M.H.

General

Appeal for fundamental research. HERBERT HOOVER. *Jour. Applied Physics*, **10**, 688–92 (1939).—In the U. S. there are about 2000 laboratories of applied science with an income of probably $300,000,000 a year. The pure science research is dependent largely on universities, and its budget certainly does not amount to $20,000,000 a year. H. pleads for more support for pure science research. A.P.

Axial balance in multistage centrifugal pumps. A. PETERSON. *Combustion*, **10** [9] 37–40 (1939).—P. reviews briefly the means that have been employed to counterbalance or eliminate hydraulic thrust in multistage pumps, particularly those operating under high pressure. He describes and discusses in detail a method by which automatic balance is attained by means of disks and a leak-off opening around the shaft, without the use of a thrust bearing. H.E.S.

Calculation of the dispersion of flue dust and cinders from chimneys. HUBER O. CROFT. *Trans. Amer. Soc. Mech. Engrs.*, **57** [1] 5–10 (1935).—Comparisons of different equations for the fluid resistance to falling particles are made, and a new equation is suggested. Using this equation and assuming values of the other variables mentioned, C. demonstrates a method for calculating the annual dust loading at different distances from a chimney. Illustrated. F.G.H.

Chain or traveling-grate stokers. GOSTA ANBRO. *Trans. Amer. Soc. Mech. Engrs.*, **60** [1] 1–3 (1938).—Illustrated. F.G.H.

Deaerators and their applications. E. S. DAUGHERTY AND C. E. JOOS. *Combustion*, **10** [8] 31–36 (1939).—The necessity of removing dissolved oxygen and carbon dioxide from boiler feed water in order to prevent corrosion is discussed. The operation and application of different types of deaerators are explained, and typical layouts for central stations and industrial plants wherein such apparatus forms a part of the feed-water cycle are given. H.E.S.

Decreasing the total cost of labor in a glass bottle plant. ANON. *Ceram. Ind.*, **29** [6] 433–39 (1937).—The Obear-Nester Glass Co. of East St. Louis, Ill., has introduced a method whereby one man performs the charging operation for a tank of the same size as that formerly requiring 4 or 5 laborers using wheelbarrows. A magnetic drum re-

moves bottle caps from the crushed cullet added to the batch. A conveyer system delivers paper cartons to the packers at the ends of the lehrs. Illustrated. E.J.V.

Defining equitable limits of dust emission from stacks. P. H. HARDIE. *Mech. Eng.*, **61** [12] 895–96 (1939). F.G.H.

Direct firing of pulverized anthracite silt. MARTIN FRISCH. *Trans. Amer. Soc. Mech. Engrs.*, **58** [3] 177–84 (1936).—F. describes a recent development in the burning of pulverized fuels. Illustrated. F.G.H.

Distribution of air to underfeed stokers. A. S. GRISWOLD AND H. E. MACOMBER. *Trans. Amer. Soc. Mech. Engrs.*, **58** [1] 13–24 (1936).—Illustrated. F.G.H.

Efficiency comparisons of turbine generators and generating stations. J. F. FIELD. *Combustion*, **10** [8] 37–39 (1939).—F. points out the inadequacy of the simple Rankine cycle as a basis for comparing the performance of turbine generators in which steam is extracted for feedwater heating. He suggests a modification of the Rankine cycle to allow for both reheating of the steam and feed heating by extraction in an assumed infinite number of reversible stages. H.E.S.

Forced-draft spreader stoker. J. F. BARKLEY. *Trans. Amer. Soc. Mech. Engrs.*, **59** [4] 259–66 (1937).—B. discusses the types of spreader stokers in use and their adaptability for different boiler installations and for burning different grades of fuel. Illustrated. See "Smoke–," *Ceram. Abs.*, **18** [5] 142 (1939). F.G.H.

Hardening concrete by silica treatment. A. DEBECQ. *Verre & Silicates Ind.*, **10** [28–30] 312–13 (1939).—Neutral liquid sodium silicate (38 to 40° Bé) whose molecular ratio is higher than $3(SiO_2/Na_2O)$ and in which the free alkalinity expressed by NaOH is less than 0.57% is the most suitable silicate for hardening the surfaces of concrete and soft materials. Best results are obtained with the following method: (1) remove oil and grease, (2) brush the surface carefully, (3) apply a first coat composed of 2 parts water (free from acid or clay impurities) and 1 part sodium silicate, (4) after this coat has penetrated, apply a second coat of a mixture of equal parts of the silicate and water, and (5) after penetration, apply a layer of the silicate alone. Surfaces so treated have a higher resistance to corrosion. Results of experiments directed by Verly at the Laboratory for Testing Materials of the Royal Military School (Belgium) are given. M.V.C.

Identification of aluminum hydrate films of importance in silicosis prevention. L. H. GERMER AND K. H. STORKS. *Ind. Eng. Chem., Anal. Ed.*, **11** [11] 583–92 (1939).—Identification of aluminum hydrate films upon silica by means of electron diffraction methods is discussed in detail. Illustrated. F.G.H.

Industrial power. C. W. E. CLARKE. *Combustion*, **10** [7] 21–27 (1939).—Among the subjects discussed are steam cycles adapted to industrial power plants, together with examples of each, types of turbine generators, steam-generating equipment, fuels and their utilization, boiler feed-water treatment, and evaporators. The economic aspects of industrial power engineering are stressed. H.E.S.

Lignite, a grate-fired fuel of the future in the Southwest. CARL J. ECKHARDT, JR. *Trans. Amer. Soc. Mech. Engrs.*, **61** [8] 657–64 (1939).—Illustrated. F.G.H.

Load distribution on turbine generators. Y. C. LU. *Combustion*, **10** [7] 28–30 (1939).—In contrast to the usual procedure of computing incremental input based on steam rate test data, which involves corrections for back pressure as applied to several units, L. outlines a method based on figures taken from the daily log sheets for one year which include condenser performance. This makes it possible to correct the turbine test data for circulating water temperature and to treat both turbine and condenser as a single unit. H.E.S.

Modern boiler furnaces. E. G. BAILEY. *Trans. Amer. Soc. Mech. Engrs.*, **61** [7] 561–76 (1939).—Illustrated. F.G.H.

Problems in heat exchange and pressure drop. LEO FRIEND AND W. E. LOBO. *Ind. Eng. Chem.*, **31** [5] 597–607 (1939).—The mathematical treatment of engineering subjects is rapidly becoming a procedure of industrial importance and is so recognized by many successful industrial executives. An example of the way in which this treatment may be applied is presented. It is designed to be of value particularly to the executives of the older school who will welcome the opportunity to become more familiar with current mathematical engineering technique. To give examples of the use of important fundamental engineering equations, two problems involving heat transfer and pressure drop are presented. The first covers the design of a double-pipe multitubular exchanger and the calculation of required heating surface and pressure drop; the second deals with the pressure drop of a gas stream passing through a packed tube. Illustrated. F.G.H.

Selection of coal for pulverized firing. B. E. TATE. *Trans. Amer. Soc. Mech. Engrs.*, **60** [1] 11–16 (1938).—Illustrated. F.G.H.

Temperature and combustion rates in fuel beds. MARTIN A. MAYERS. *Trans. Amer. Soc. Mech. Engrs.*, **59** [4] 279–88 (1937).—Illustrated. F.G.H.

Trends in fuel-burning equipment and furnace design as shown by recent eastern-seaboard applications. RALPH D. BOOTH. *Trans. Amer. Soc. Mech. Engrs.*, **61** [2] 81–87 (1939).—Illustrated. F.G.H.

Underfeed stokers from the standpoint of coal selection. J. E. TOBEY. *Trans. Amer. Soc. Mech. Engrs.*, **60** [1] 17–24 (1938).—Illustrated. F.G.H.

SEPARATE PUBLICATION

Active List of Permissible Explosives and Blasting Devices Approved Prior to June 30, 1939. ANON. *U. S. Bur. Mines Repts. Investigations*, No. 3471, 25 pp. Free. The Bureau's requirements regarding stemming are emphasized, and details of the permissible conditions governing the use of nine models of blasting devices are included. This report supersedes *Repts. Investigations*, No. 3421. R.A.H.

PATENTS

Forming lightweight fluid-pervious ceramic bodies. E. T. HERMANN. U. S. 2,180,757, Nov. 21, 1939 (July 26, 1937).—The method of manufacturing a ceramic pervious body comprises shaving of agglomerate particles from a mass of plastic argillaceous material in such condition that the particles have no tendency to plastically interbond on contact with each other, subjecting the particles to a heat treatment at a temperature sufficient to cause each particle to develop an internal bond and produce significant firing shrinkage in the particles but insufficient to cause a bond between the particles, coating the fired particles with an aqueous medium containing an argillaceous bonding material so as to obtain plastic interbonding of the particles, forming the coated particles into a body having a high percentage of mutually intercommunicating voids and a multiplicity of internal surfaces defining the voids, and then causing the particles to interbond to form an integral body by heat treatment thereof at a temperature in excess of the first-named temperature.

Manufacturing porous ceramic objects. COMPAGNIE GÉNÉRALE D'ELECTRO-CÉRAMIQUE. Fr. 849,465, Aug. 1, 1938. D.A.B.

Neutralizing siliceous material effects. J. J. DENNY AND W. D. ROBSON. Can. 384,199, Sept. 26, 1939 (June 18, 1937).—A method for neutralizing the fibrosis-producing properties of finely pulverized siliceous materials in the lungs comprises intimately associating aluminous material therewith. G.M.H.

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